

CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

This chapter describes the U.S. Department of Energy's (DOE) proposed action; that is, the management of spent nuclear fuel (SNF) at the Savannah River Site (SRS). Technical terms are defined in the Glossary.

2.1 Proposed Action

As described in Chapter 1, SRS will receive aluminum-based SNF from foreign research reactors, domestic research reactors, and other DOE sites. DOE will have to manage this fuel, in addition to some SNF already stored at the Site, in a manner that will protect human health and the environment. Additionally, DOE is committed to avoiding indefinite storage at SRS of SNF that is in a form unsuitable for final disposition. Therefore, DOE's proposed action is to safely manage SNF that is currently located or expected to be received at SRS, including treating or packaging aluminum-based SNF for possible offsite shipment and disposal in a geologic repository, and packaging non-aluminum clad fuel for on-site dry storage or offsite shipment.

In the Record of Decision (ROD) for the Final Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor SNF (61 FR 25092), DOE stated that it would embark on an accelerated program at SRS to identify, develop, and demonstrate one or more non-chemical processing, cost effective treatment or packaging technologies to prepare aluminum-based foreign research reactor spent nuclear fuel for ultimate disposition.

Based on that decision, DOE's proposal is to select a new non-chemical processing technology that would put aluminum-based foreign research reactor SNF into a form or container suitable for direct placement in a geologic repository. Treatment or conditioning of the fuel would address potential repository acceptance criteria and potential safety concerns. Implementing the new non-chemical processing treatment or packaging

technology would allow DOE to manage the SNF in a road-ready condition at SRS in dry storage pending shipment offsite.

Because of the similarity of the material, DOE proposes to manage the other aluminum-alloy SNF that is the subject of this EIS (domestic research reactor and DOE reactor fuels) in the same manner as the foreign research reactor fuels.

In the Final Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor SNF Record of Decision, DOE stated that, should it become apparent by the year 2000 that DOE will not be ready to implement a new SNF treatment technology, DOE would consider chemically processing foreign research reactor SNF in F Canyon. The Final Environmental Impact Statement on a Proposed Nuclear Nonproliferation Policy Concerning Foreign Research Reactor SNF Record of Decision described the possible use of F Canyon for SNF processing based on a preliminary concept to consolidate all processing operations in one canyon. Subsequent review has shown that consolidating highly enriched uranium spent fuel processing operations in F Canyon would not be practical due to criticality considerations and process capacity restrictions associated with the plutonium-uranium extraction system used in F Canyon. Thus, DOE is now proposing to use H Canyon to chemically separate highly enriched uranium spent fuel.

DOE also committed that any decision to use conventional chemical processing would consider the results of a study (62 FR 20001) on the non-proliferation, cost, and timing issues associated with chemically processing the fuel. DOE stated that any highly enriched uranium separated during chemical processing would be blended down to low enriched uranium.

DOE has included chemical processing as a management alternative in this EIS, although

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DOE's preference is to use non-chemical operations processes. DOE proposes to use conventional processing to stabilize some materials before a new treatment facility is in place. The rationale for this is to avoid the possibility of urgent future actions, including expensive recovery actions that would entail unnecessary radiation exposure to workers, and in one case, to manage a unique waste form (i.e., core filter block).

prepare and package aluminum-based SNF for disposition in a geologic repository. Another technology option, Repackage and Prepare to Ship, is pertinent only to non-aluminum-clad SNF and programmatic material that would be shipped offsite. These three technology options are discussed under the New Packaging Technology options section (Section 2.2.3) of this EIS.

Nine of the technology options are potential processes for the treatment of aluminum-based SNF. These are Melt and Dilute, Press and Dilute, Chop and Dilute, Plasma Arc Treatment, Glass Material Oxidation and Dissolution System, Dissolve and Vitrify, Electrometallurgical Treatment, Can-in-Canister, and Chloride Volatility. DOE has consolidated seven of these processing technology options into four categories for analysis in this EIS. The Press and Dilute and the Chop and Dilute options are similar, so DOE has represented them for analysis as Mechanical Dilution. The Plasma Arc Treatment, the Glass Material Oxidation and Dissolution System, and the Dissolve and Vitrify options use processes that produce a product with properties similar to that produced at the Defense Waste Processing Facility (DWPF) at SRS. Therefore, DOE has represented these three as the Vitrification option. The Melt and Dilute and the Electrometallurgical Treatment options are analyzed separately. The new treatment options are discussed under the New Processing Technology section of this EIS (Section 2.2.4).

DOE considered the remaining two technology options but dismissed them from analysis in this EIS. With Chloride Volatility, SNF would react with chlorine gas at high temperatures to form volatile chlorides. The uranium, aluminum, fission products, and transuranics would be separated from each other by cooling and distillation. This technology is very immature

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The limited proposed canyon processing actions is not expected to extend the operating schedules for these facilities beyond the current planning basis. Processing would eliminate potential health and safety vulnerabilities that could occur prior to the availability of a new SNF treatment technology. In the event a new treatment process becomes available, the SNF with potential health and safety vulnerabilities could be processed using the new treatment technology.

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Previous DOE management decisions on disposition of SNF are outlined in Section 1.1 and Appendix C, Section C.1.2. Relevant National Environmental Policy Act documents are discussed in Section 1.6.

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2.2 Spent Nuclear Fuel Management Technology Options

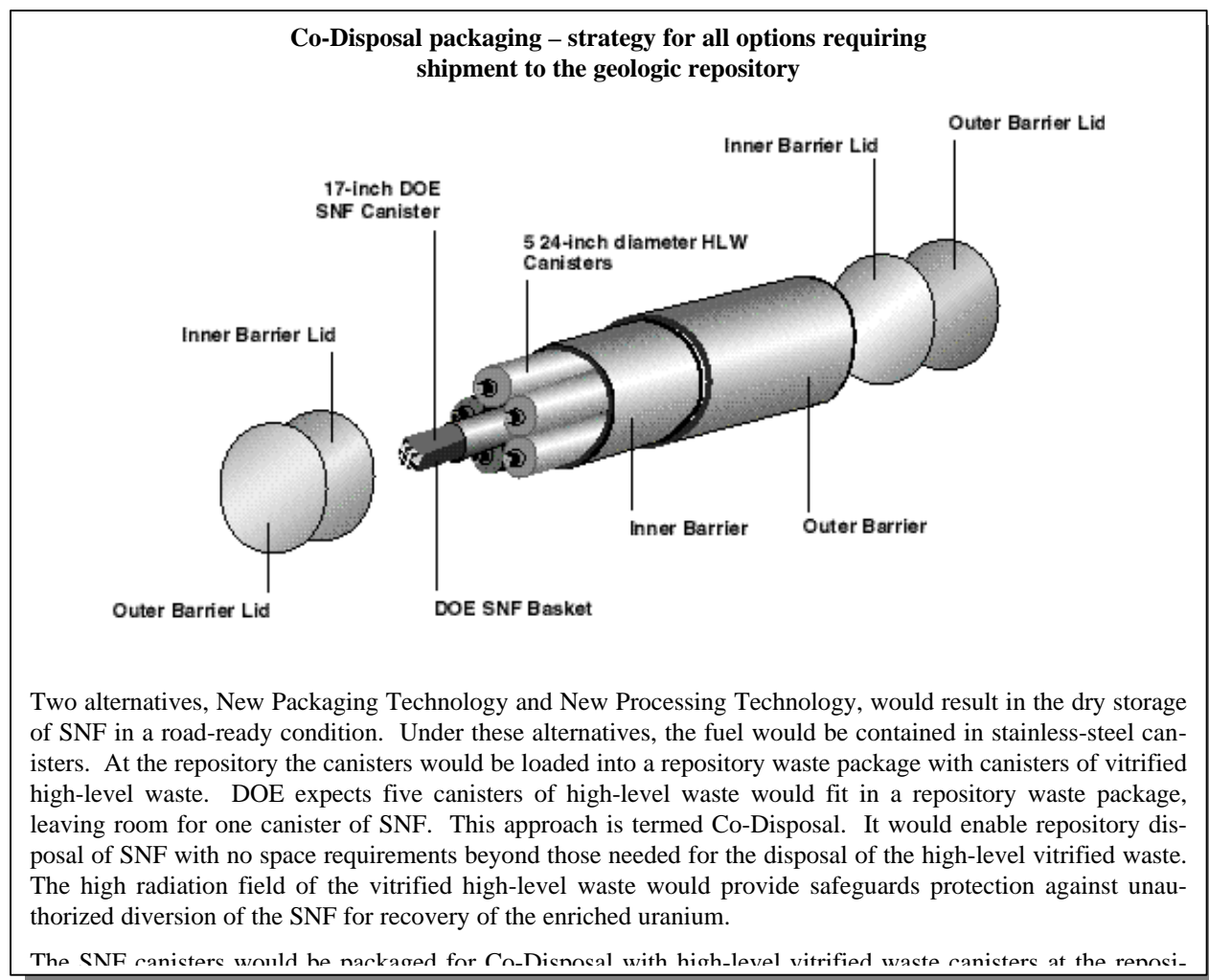
DOE has identified 11 potential treatment and packaging technology options in addition to conventional processing that could be used to prepare aluminum-based SNF at SRS for final disposition in a geologic repository. All of the technology options are discussed in Appendix A of this EIS.

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Two of the options, Direct Disposal and Direct Co-Disposal, are non-destructive methods to

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in terms of actual development and testing and the potential for implementation in a timely manner is very uncertain. In addition, this method of chemical separation offers no advantage over conventional processing and DOE eliminated the option from further consideration.

The second technology option dismissed from analysis was Can-in-Canister, under which DOE would place SNF in a can (in an amount that would not pose criticality concerns), place the can in a stainless-steel canister, and fill the canister with vitrified high-level waste. This technology was originally developed as a means for disposing of immobilized plutonium. Because plutonium does not emit intense penetrating radiation, the high radiation field of the vitrified high-level waste would render the plutonium inaccessible. However, a more cost-effective and

technologically viable way to protect the SNF with radiation fields is to employ the co-disposal concept. Should the Can-in-Canister method be used with aluminum SNF, the high temperature of the molten glass could melt the aluminum in the fuel, changing the geometry of the fuel matrix in an uncontrolled fashion. Therefore, this option could pose significant risks to human health and the environment, and for that reason was not considered a reasonable alternative.

The New Packaging Technology options and the New Processing Technology options consist of several technology options that DOE has not previously applied to the management of aluminum-based SNF for the purpose of ultimate disposition. As a result, DOE believes that the highest confidence of success and greatest technical suitability lies with options that have relatively sim-

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ple approaches (i.e., Direct Disposal, Direct Co-Disposal, Melt and Dilute, and Press and Dilute).

2.2.1 REPOSITORY CONSIDERATIONS

As discussed in Section 2.1, part of DOE's proposed action is to prepare SNF to meet the requirements that the Department anticipates will be applicable to material to be placed in a geologic repository. Any technology that DOE implements must be able to provide a product that is compatible with such criteria. DOE must rely on reasonable assumptions about what the acceptance criteria would include when making decisions on SNF treatment technologies. As described in Chapter 1, DOE anticipates that eventually it will place its aluminum-based SNF inventory after treatment or repackaging in a geologic repository.

As the operator of any geologic repository for SNF, DOE would be responsible for developing acceptance criteria for the material that would be placed in the repository. However, the U.S. Nuclear Regulatory Commission (NRC) would be responsible for licensing the repository. Therefore, DOE is working closely with the NRC to develop acceptance criteria. DOE will provide the NRC with characterization data for material that would be prepared for disposal in a geologic repository. At this time, acceptance criteria need to be conservative because of uncertainties concerning any engineered or natural barriers at a repository. However, as repository and packaging designs evolve, the criteria will become more detailed. Fuel characterization data will need to be detailed enough to verify that each element or canister falls within the ultimate acceptance criteria. Such detail, however, is not currently available. Final acceptance criteria will not be available until after NRC issues its authorization, based on the successful demonstration of safe, long-term performance of the candidate repository in accordance with NRC regulations. Until such time, the preliminary acceptance criteria tend to be conservative to allow for uncertainties in performance of engineered or natural barriers and how such performance may impact public

and worker health and safety, and material isolation.

DOE has performed preliminary evaluations of the expected SNF characteristics (DOE 1995a, 1996a). Those evaluations indicated that the SNF to be placed in the repository would have to meet requirements for the following characteristics:

Packaging

- Dimension and weight limits
- Material compatibility
- Thermal limits
- Internal gas pressure limits
- Labeling
- Handling ability
- Waste isolation

Contents

- Solid material – no particulates
- Noncombustible
- No free liquids
- No hazardous waste (as defined by the Resource Conservation and Recovery Act)

Chemical reactivity

- Not chemically reactive
- Nonpyrophoric
- Nonexplosive

Nuclear material safeguards

- Reduced uranium-235 enrichment
- Self-protecting radiation fields
- Tamper-proof seals

Criticality control

- Limits on nuclear reactivity by controlling amount of uranium and its enrichment (see Text Box on page 2-5)

Proliferation and Criticality Concerns for SNF Disposal

Preparation of SNF for disposal in a geologic repository requires consideration of the risk of a disruptive nuclear criticality. Criticality risk is defined as the potential for a neutron-induced self-sustaining fission reaction like that which occurs in a nuclear reactor. Nuclear criticality in the SNF would be due to uranium enriched in the fissile nuclide uranium-235 with the remainder being principally non-fissile uranium-238. Characteristic enrichment levels in these fuels are designated as follows (DOE 1996b).

	Percent uranium-235
Highly enriched uranium (HEU)	>20-93
Low enriched uranium (LEU)	>2-≤20
Commercial power reactor fuel	<2-4
Very low enriched uranium (VLEU)	≤2
Natural uranium (NU)	0.72
Depleted uranium (DU)	Typically 0.18

Concern for the enrichment level of the fuel arises from two considerations: (1) weapons material proliferation policy and (2) criticality control during storage, transportation, and repository disposal. The high-enriched uranium fuels are generally considered to present unacceptable proliferation risks, unless otherwise protected. Isotopic dilution of the high-enriched uranium fuels to 20 percent uranium-235 during treatment for repository disposal satisfies requirements for protection against this proliferation risk.

One approach to control the potential for a nuclear reaction during storage, transport, and repository disposal of the SNF (high-enriched uranium or low-enriched uranium) is addressed by incorporation of neutron-absorbing poison materials in the waste form or containers, by reduction of enrichment levels to the extent practical (2 to 20 percent), and by limiting the mass loading of fissile uranium-235 in the primary waste form canisters. Provisional limits for fissile mass loadings have been specified as follows (DOE 1996b):

	Allowable fissile mass loading (kg U-235) per canister*
HEU	14.4
LEU	43
VLEU	200

*Larger quantities of fissile U-235 in the canister are permitted at lower enrichment levels because of neutron escape or absorption in non-fissile material.

In accord with these specifications, the SNF processed for Direct Co-Disposal (with no dilution of highly enriched uranium) would require incorporation of neutron poisons in the waste canister and possibly smaller canisters to meet fissile mass loading limits. The processes under the New Processing Technology, which would achieve enrichment levels of 20 percent or less, would generate canisters within the low-enriched uranium fissile mass loading limits but could require incorporation of poison materials for additional criticality

Radiation

- Radiation field limits
- Canister surface contamination limits

The preliminary acceptance criteria describe the physical, chemical, and thermal characteristics to which spent nuclear fuel, high-level waste, and associated disposable canisters must conform for

emplacement in the repository. The preliminary criteria are organized into four categories:

- General/Descriptive
- Physical/Dimensional
- Chemical/Compatibility
- Thermal/Radiation/Pressure

Disposability Assessment: Aluminum-Based Spent Nuclear Fuel Forms (WSRC 1998a) provides a technical assessment of the Melt-and-Dilute and Prepare for Direct Disposal/Direct Co-Disposal technologies against these preliminary criteria. This assessment is based on results of several analytical and experimental –investigations at SRS, and criticality calculations. The Disposability Assessment concluded:

Both Melt-Dilute and Direct [disposal] forms [for aluminum-alloy SNF] in disposable containers can meet the requirements of the Draft Standards for Spent Nuclear Fuel in Disposable Canisters. Completed analyses indicate that the Melt-Dilute form of eutectic composition (13.2 percent [uranium]) and containing less than 20 percent ²³⁵U [uranium-235] meets the requirements of the draft standards. Additional criticality analysis of the Melt-Dilute form and HLW [high-level waste] degraded within a waste package are needed for the disposability assessment and are being scheduled for FY00 and subsequent years as part of the development process for the full scale facility. The Melt-Dilute form is flexible in that additional dilution or the addition of neutron poisons to the Melt-Dilute product can be readily made, if necessary.

The Direct form in disposable canisters can meet all requirements of the Draft Standards. Criticality analyses have identified that neutron poison additions are needed to preclude criticality of degraded Al-SNF [aluminum based spent nuclear fuel] within a canister and of degraded Al-SNF and HLW within a waste package. A method is needed to incorporate neutron poisons into the canisters in the demonstration that reactivity of all possible configurations is within the acceptable limit. Several poison materials have been suggested and are being evaluated and tested for compatibility with the Al-SNF. These activities will

continue throughout the development process for the full scale melt and dilute facility.

Based on the preliminary criteria and the conclusions in the Disposability Assessment, preliminary judgments can be made regarding the acceptability for disposal of the final waste forms produced under the other technologies evaluated in this EIS. Final disposal requirements will be specified by NRC; currently the final waste form produced under the Conventional Processing technology (borosilicate glass) is the best demonstrated available technology for treatment of high-level waste (55 FR 22520). Therefore, DOE has high confidence that this waste form would be acceptable for disposal in a geologic repository. The final waste form produced under the Vitrification technologies and Electrometallurgical Treatment technologies is similar to that produced under the Conventional Processing technology; thus, DOE also would have high confidence in the acceptability of their final products. For Vitrification technologies, criticality and nonproliferation concerns would need to be addressed by the dilution of the highly-enriched uranium to low-enriched uranium.

The solid form with low enrichment that would be the product of mechanical dilution could be acceptable for storage in a geologic repository. However, this technology would not be as effective from a nuclear nonproliferation perspective as other treatments (such as Melt and Dilute) because of the potential to separate the pressed or chopped depleted uranium and SNF.

Nuclear materials safeguards are one of the most important issues to be addressed for both onsite storage and transportation to a repository. Much of the aluminum-based SNF contains appreciable quantities of highly enriched uranium or plutonium. In addition to secure management, there are two basic methods for ensuring that these fissile materials have the proper safeguards: (1) reducing the uranium-235 enrichment or (2) making the fuel self-protecting. Reduced uranium-235 enrichment makes the fissile materials incapable of producing a nuclear explosion.

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Reenrichment would require a massive commitment of resources not available to most nations. "Self-protecting" means the radiation fields around the fuel are sufficiently high that recovery of the fissile materials would be impossible without the considerable resources of facilities such as those at SRS.

Finally, the integrity of the fuel form that is stored after treatment pending shipment to a repository must be sufficient to ensure safe interim storage and to prevent degradation of design features that may be relied upon in the repository.

TC | Because the melt and dilute waste form could eventually be disposed of in a geologic repository, DOE-SR signed in August 1997 a Memorandum of Understanding with the NRC for its review of the research effort that DOE-SR is conducting. DOE-SR has provided the NRC with several technical reports on the results obtained from the research effort. Based upon its initial review, the NRC in a June 1998 letter (Knapp 1998) stated that "both the direct co-disposal and melt-dilute options would be acceptable concepts for the disposal of aluminum-based research reactor SNF in the repository." Additionally, as research efforts yield new findings, DOE is providing the information to the NRC.

TC | DOE would not implement a treatment technology option unless it has a high degree of confidence that the technology option would produce a final form that was compatible with what DOE believes the repository acceptance criteria will be. In order to ensure that the treatment technology DOE could select will produce a product that is likely to meet the acceptance criteria, DOE-SR is working with the NRC to obtain comments on the research and development work that DOE will perform to establish treatment technology specifications. To provide additional confidence in the suitability of new treatment technologies, DOE requested that the National Academy of Sciences (NAS) evaluate and provide recommendations regarding DOE's aluminum-based SNF disposition technical development program. Re-

sults of the NAS review are summarized in Section 2.6.1.

2.2.2 FACILITIES

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Under the alternatives considered in this EIS, the Department could need a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility. A Transfer and Storage Facility for SNF would provide remote handling and heavy lifting capability, hot cells, and space to receive SNF shipments; place the SNF in interim storage as needed; open the shipping containers; sample and analyze the fuel; crop end fittings if necessary; vacuum-dry the SNF; repackage the fuel into storage canisters; and place the repackaged fuel in dry interim storage. Section 2.3.2.1 provides information on the Transfer and Storage Facility. A Transfer, Storage, and Treatment Facility would provide the capability to implement the options of the New Processing Technology. Section 2.3.2.2 provides more information on the Transfer, Storage, and Treatment Facility.

For all technologies, DOE would continue to use the Receiving Basin for Offsite Fuel and the L-Reactor Disassembly Basin for currently stored SNF and to receive and store incoming fuel. If DOE built the Transfer and Storage Facility, newly received fuel could go to that facility, and the inventory in the wet basins would gradually be moved to new dry storage. DOE intends to discontinue wet storage by 2009 (DOE could continue to use the L-Reactor Disassembly Basin for SNF receipt and unloading if Building 105-L was modified as a Transfer, Storage, and Treatment Facility [see Section 2.3.2]).

All currently stored SNF at the SRS is located in the Receiving Basin for Offsite Fuel or the L-Reactor Disassembly Basin (generically termed "wet basins" in this EIS). DOE initially would receive and store incoming fuel either in the L-Reactor Disassembly Basin or the Receiving Basin for Offsite Fuel and begin construction of a new Transfer and Storage or Transfer, Storage, and Treatment Facility. Fuel would be transported from wet storage basins to the new facility as prescribed to prepare the material for disposi-

tion. Radiological consequences of the on-site transportation of the spent nuclear fuel, under both incident-free and accident conditions are projected in Section 4.1.1.7.

2.2.3 NEW PACKAGING TECHNOLOGY OPTIONS

In this section DOE describes technology options (Direct Disposal/Direct Co-Disposal) that could be used to prepare aluminum-based SNF for placement in a geologic repository and a technology option (Repackaging and Prepare to Ship) that DOE could use to transfer non-aluminum-clad SNF and programmatic material to dry storage pending offsite shipment.

The Direct Disposal/Direct Co-Disposal technology has the advantage of being one of the simplest to implement because it would not require a Treatment Facility, nor would it entail many operational activities. However, several potential technical issues associated with the repository must be resolved. The acceptability of aluminum-based, highly-enriched uranium fuel in a geologic repository is uncertain because of criticality concerns. DOE proposes to address this matter by limiting the amount of uranium permitted in a canister of fuel and by adding a neutron poison. Hydrogen could be produced from radiolysis of bound water in the aluminum metal fuel; however, DOE could minimize hydrogen production by adequate drying and venting, if necessary. The level of SNF characterization and certification requirements is uncertain. DOE expects the operational history of the fuel and some statistical analysis, combined with an evaluation of the more important chemical and physical characteristics (e.g., original fissile material loading, post irradiation burn-up and radiation levels) should be sufficient to characterize the fuel. The need for more detailed characterization information, based on regulatory requirements that will be developed in the future, could require much more costly and time-consuming analysis for each fuel.

2.2.3.1 Prepare for Direct Disposal/Direct Co-Disposal

In the Transfer and Storage Facility, the SNF would be cropped (cropping removes the end pieces of the assembly; see Glossary), vacuum dried, and placed in a stainless-steel canister with a neutron poison. The canisters would be filled with an inert gas, welded closed, and placed in dry storage to await shipment to the geologic repository. Some of the uranium oxide and uranium silicide fuels could require cutting or other resizing to fit into the canisters. As an alternative, special packaging could be used for these oversized fuels.

From an SRS perspective, Direct Disposal and Direct Co-Disposal are identical except for a slight difference in number of canisters produced. The analyses in this EIS would apply equally to either technology. If DOE used canisters with a diameter of about 17 inches (43 centimeters), it could co-dispose (see text box on page 2-3 on the co-disposal concept) the canisters at the repository with vitrified high-level waste prepared in DWPF (Direct Co-Disposal). Otherwise, using 24-inch (61-centimeter) diameter canisters, DOE could dispose of the fuel between waste packages of commercial SNF (Direct Disposal).

Due to the nature and form of the SNF to be managed at SRS, DOE does not expect the Direct Disposal/Direct Co-Disposal technology option would be applicable to all the aluminum-based SNF considered in this EIS. Table 2-1 presents an explanation of the SNF that DOE considers appropriate for the Direct Disposal/Direct Co-Disposal option.

Figure 2-1 shows the Direct Disposal/Direct Co-Disposal option. Appendix A provides a more complete discussion of Direct Disposal and Direct Co-Disposal.

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2.2.3.2 Repackage and Prepare to Ship to Other DOE Sites

This technology option would apply to two specific fuel groups, and this is the only option considered for these fuel groups.

- DOE has designated management responsibilities for the stainless-steel and zirconium-clad fuels (Group F) to the Idaho National Engineering and Environmental Laboratory (60 FR28680). DOE analyzed the environmental impacts of shipping these non-aluminum-clad fuels to the Idaho National Engineering and Environmental Laboratory in the Programmatic SNF EIS (DOE 1995b).

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- The Higher Actinide Targets would be stored pending an evaluation of their disposition. Under the Repackaging and Prepare to Ship to Other DOE Sites technology option, DOE evaluates repackaging the Mark-51 and other targets to place them in a new dry storage facility in the event disposition decisions have not been made by the time an SRS dry storage facility is operational.

DOE would not apply the Repackaging and Prepare to Ship option to the Mark-18 targets due to potential health and safety vulnerabilities as described in Section 1.5 of this EIS.

In the Transfer and Storage Facility, the SNF and the Mark-51 and other targets could be cropped, vacuum dried, and placed in stainless-steel canisters, possibly with a neutron poison. The canisters would be filled with an inert gas, welded closed, and placed in dry storage to await shipment offsite. Figure 2-2 shows the Repackage and Prepare to Ship option which would be implemented only in parallel with an alternative that required the construction of a Transfer and Storage Facility or Transfer, Storage, and Treatment Facility. A new facility would not be constructed solely to repackage non-aluminum-based fuels and the higher actinide targets.

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2.2.4 NEW PROCESSING TECHNOLOGY OPTIONS

The New Processing Technology options would reduce the uncertainty associated with placing aluminum SNF in a geologic repository because criticality concerns would be reduced through the opportunity to adjust enrichment, add neutron absorbers, and better control geometry.

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Under these technology options, DOE initially would receive and store incoming fuel either in the L-Reactor Disassembly Basin or the Receiving Basin for Offsite Fuel. DOE would construct and operate a Transfer, Storage, and Treatment Facility (Section 2.3.2.2) to receive later shipments, and would begin to transfer the fuel inventories in the existing storage pools to this facility. DOE could use the dry storage capacity of the facility to store SNF awaiting processing and to store the processed fuel form in a road-ready condition awaiting shipment to the geologic repository.

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If a new facility was built, DOE would phaseout operation of the L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuel by 2009. In the event that Building 105-L was modified to function as the Transfer, Storage, and Treatment Facility, SNF would continue to be received and unloaded in the L-Reactor Disassembly Basin, but long-term SNF storage in the basin and in the Receiving Basin for Offsite Fuel would be phased out. The Transfer, Storage, and Treatment Facility could be located in a new or existing facility in one of the reactor areas or in a new facility in F or H Area.

Each technology option that DOE could use in the Transfer, Storage, and Treatment Facility, except Electrometallurgical Treatment, would result in an SNF form that DOE would store in road-ready condition. The use of 17-inch (43-centimeter) diameter canisters would support the co-disposal concept; however, DOE could use other canister sizes. DOE assumed a 17-inch canister for purposes of estimating costs of each technology (see Section 2.6.5). The analyses in

this EIS would apply equally to other canister sizes.

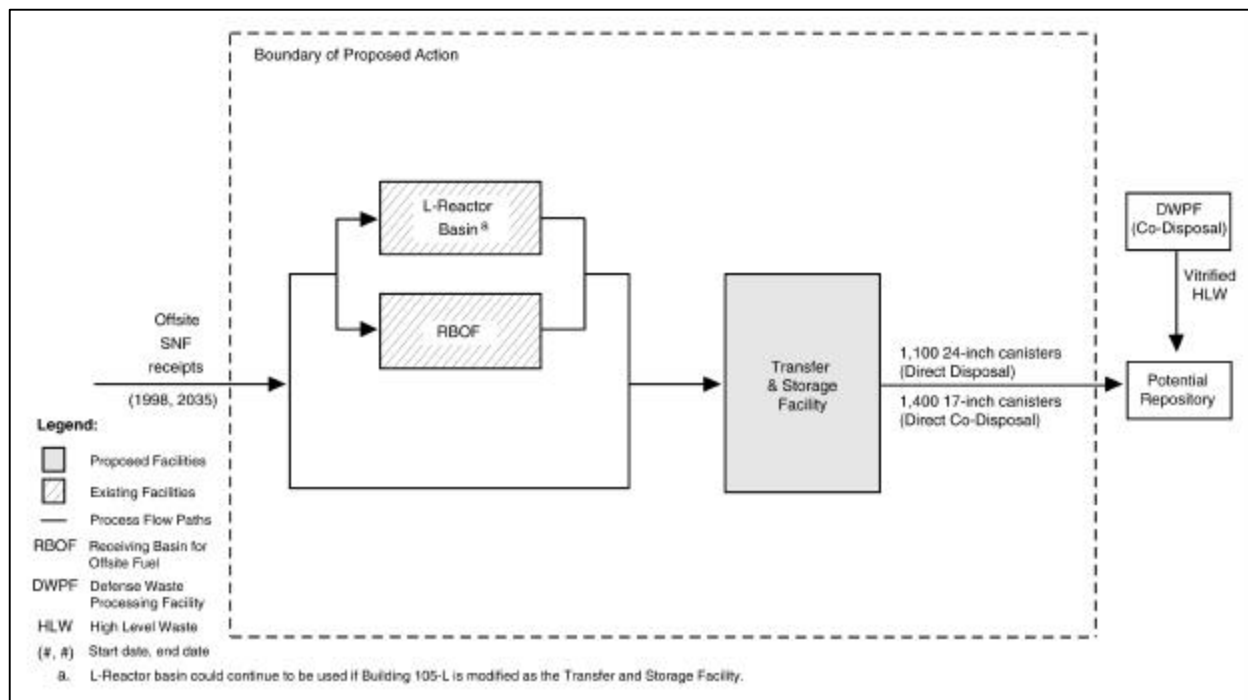
Table 2-1. Applicability commentary of the New Packaging Technology options.

	Fuel group	Prepare for Direct Disposal/Direct Co-Disposal	Repackage and Prepare to Ship to Other DOE Sites
	A. Uranium and Thorium Metal Fuels	Applies - These reactive metal fuels would require rigorous drying (hot vacuum drying) to ensure dehydrating and passivation of uranium metal for both short-term and repository storage.	Does not apply - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS. DOE would not ship aluminum-based SNF to another site for storage.
	B. Materials Test Reactor-Like Fuels	Applies - The fissile mass loading of the canisters would be limited because of criticality concerns. DOE and NRC ^a are discussing packaging restrictions which would eliminate the possibility of criticality.	Does not apply - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS. DOE would not ship aluminum-clad SNF to another site for storage.
	C. HEU/LEU ^b Oxides and Silicides Requiring Resizing	Applies - These fuels would not fit into the 17-inch (43-centimeter) diameter canister without resizing or special packaging. The highly enriched fuels present criticality concerns. The fissile mass loading of the canisters would be limited.	Does not apply - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS.
EC	D. Loose Uranium Oxide in Cans	Does not apply - Group D fuels are granular and might contain particulates. Current understanding of acceptance criteria for the geologic repository would rule out acceptance of particulate fuels.	Does not apply - The Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b) determined that DOE would manage aluminum SNF at SRS and would ship non-aluminum fuel to INEEL.
EC	E. Higher Actinide Targets	Does not apply - This fuel group will be continually wet stored until DOE decides on their final disposition.	Applies - In the future, DOE might decide to ship these targets to another DOE site. Application of this technology to Group E fuels would include only the preparation for shipment, not the shipment itself.
	F. Non-Aluminum-Clad Fuels	Does not apply - The Record of Decision for the Programmatic SNF EIS designated INEEL ^c as the location for management of non-aluminum-clad SNF. SRS activities for Group F fuels are to prepare it for shipment to INEEL.	Applies - Under the Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE 1995b), DOE would ship non-aluminum-clad spent nuclear fuel to INEEL. DOE analyzed shipment from wet basins (DOE 1995b) which could occur under the No-Action Alternative. This technology would provide an additional action of repackaging and dry-storing Group F fuel before shipment.

a. NRC = U.S. Nuclear Regulatory Commission.

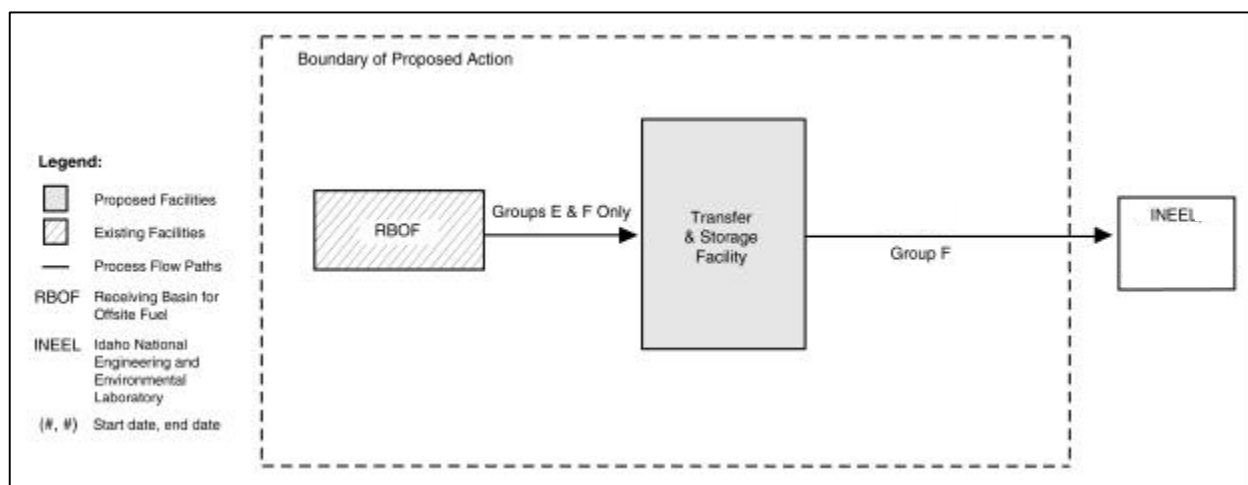
b. HEU/LEU = Highly Enriched Uranium/Low Enriched Uranium.

c. INEEL = Idaho National Engineering and Environmental Laboratory.



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Figure 2-1. New Packaging Technology – Direct Disposal/Direct Co-Disposal.



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Figure 2-2. New Packaging Technology – Repackage and Prepare to Ship to Another DOE site.

Figures 2-3 and 2-4 show the New Processing Technology options. The following sections describe the new technology options; Appendix A describes them in more detail. Table 2-2 lists the applicability of the New Processing Technology to the fuel groups described in Chapter 1.

2.2.4.1 Melt and Dilute

Under the Melt and Dilute option, DOE would receive, unload, and crop the SNF in the Transfer, Storage, and Treatment Facility and either package the fuel in canisters for placement in dry storage pending treatment or send it directly to the treatment phase. The SNF would be melted and, if highly enriched, mixed with depleted ura-

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nium and additional aluminum as necessary to produce a low-enriched uranium-aluminum melt. Neutron poison material also could be added if necessary. The low-enriched uranium product would be placed in corrosion-resistant canisters. The canisters, about 17-inch diameter by 120-inch length (43 by 305 centimeters), would be filled with an inert gas, welded closed, and placed in dry storage to await shipment to the geologic repository.

Under this option, most of the fission products would remain in the uranium-aluminum melt; however, some would be volatilized. Dilution to low enrichment would address nuclear proliferation concerns relating to transport and disposal of fuels. Both the dilution and the poison addition would address criticality concerns. Other characteristics promoting acceptability of the final form for disposal in the geologic repository are discussed in Appendix A.

Based on recent research and development work, preliminary conceptual design work, and considering aspects such as technical maturity, DOE considers Melt and Dilute to be the most viable of the technology options for implementation at SRS. DOE believes Melt and Dilute would entail the least technical risk because DOE has made substantial progress in the development of the melt and dilute process and ongoing work indicates full-scale operations that melt aluminum-based SNF and isotopically dilute the high-enriched uranium are achievable. A review by the National Academy of Sciences indicated that the Melt and Dilute process, as proposed by the SRS, should be achievable for aluminum-based SNF to be managed at SRS.

During the development of the Melt and Dilute technology, DOE may determine that, for technical, regulatory, or cost reasons, the Melt and Dilute option is no longer viable. As a back-up to Melt and Dilute, DOE will continue to pursue the Direct Co-Disposal option of the New Packaging Technology and would attempt to implement this option if Melt and Dilute were no longer feasible or preferable. Direct Co-Disposal has the potential to be the least complicated of

the new technology options. However, there is uncertainty that aluminum-based SNF, packaged according to the Direct Co-Disposal option, would be acceptable in a geologic repository. A comparison of the preferred and backup technologies for aluminum-based nuclear fuel disposal is presented in Table 2-3.

The DOE-SR and the NRC have established an agreement for the NRC to provide technical assistance in connection with the identification of potential issues relating to the placement of aluminum-based foreign and domestic research reactor spent nuclear fuel in a geologic repository. In a review of DOE's research and development work, the NRC staff indicated that both the Melt and Dilute and Direct Co-Disposal technologies would be acceptable concepts for the disposal of aluminum-based research reactor SNF in a repository (Knapp 1998).

2.2.4.2 Mechanical Dilution

For this option, DOE would use a mechanical process to consolidate the fuel and isotopically dilute the uranium-235. The process could be either Press and Dilute or Chop and Dilute (see Appendix A). The impact analyses in Chapter 4 are based on Press and Dilute because DOE believes those impacts would be representative of both technologies, which would have nearly identical process flows, facility requirements, and resulting fuel forms.

DOE would crop and cold-vacuum-dry SNF in the Transfer, Storage, and Treatment Facility and either place the fuel in canisters for dry storage pending treatment or send the fuel directly to the treatment phase for volume reduction and dilution. The Press and Dilute method would flatten fuel assemblies and press them into a laminate between layers of depleted uranium to produce packages with a low overall enrichment. The Chop and Dilute method would shred the fuel and mix it with depleted uranium. Regardless of the dilution method, DOE would package the product in 17- by 120-inch (43- by 305-centimeter) canisters. The package could contain a nuclear poi-

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son (in either the laminate or the container) to
reduce the

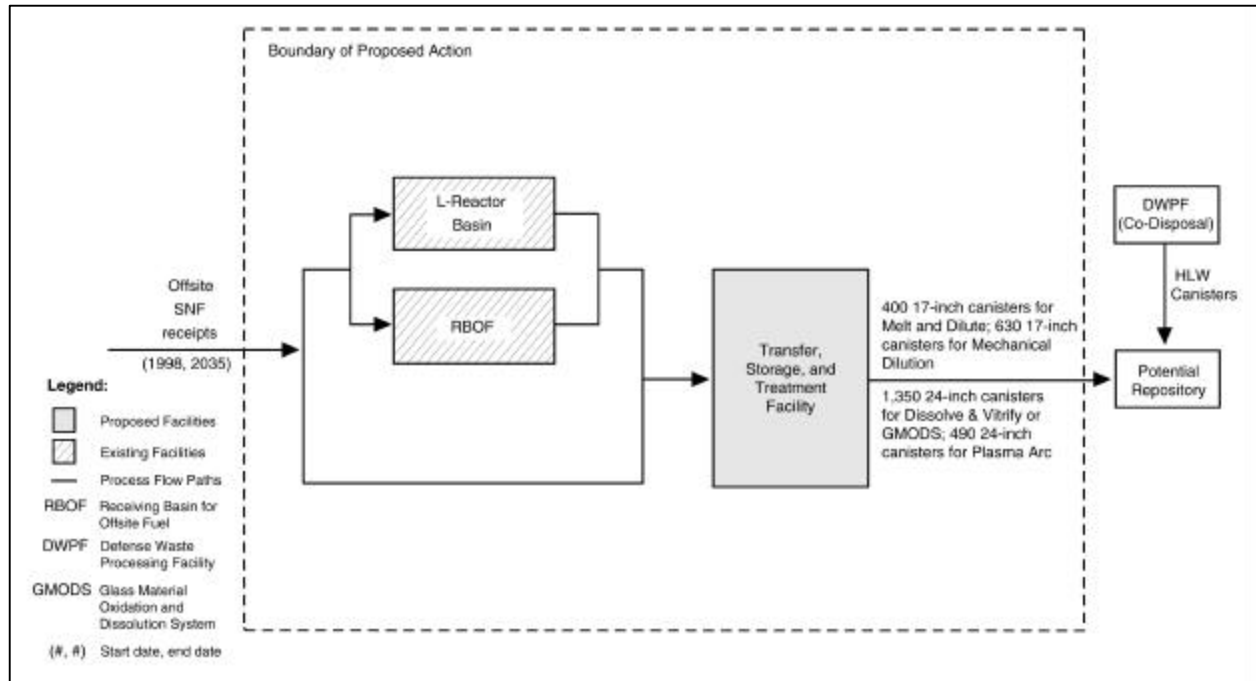


Figure 2-3. New Processing Technology - Melt and Dilute, Mechanical Dilution, Vitrification Technologies.

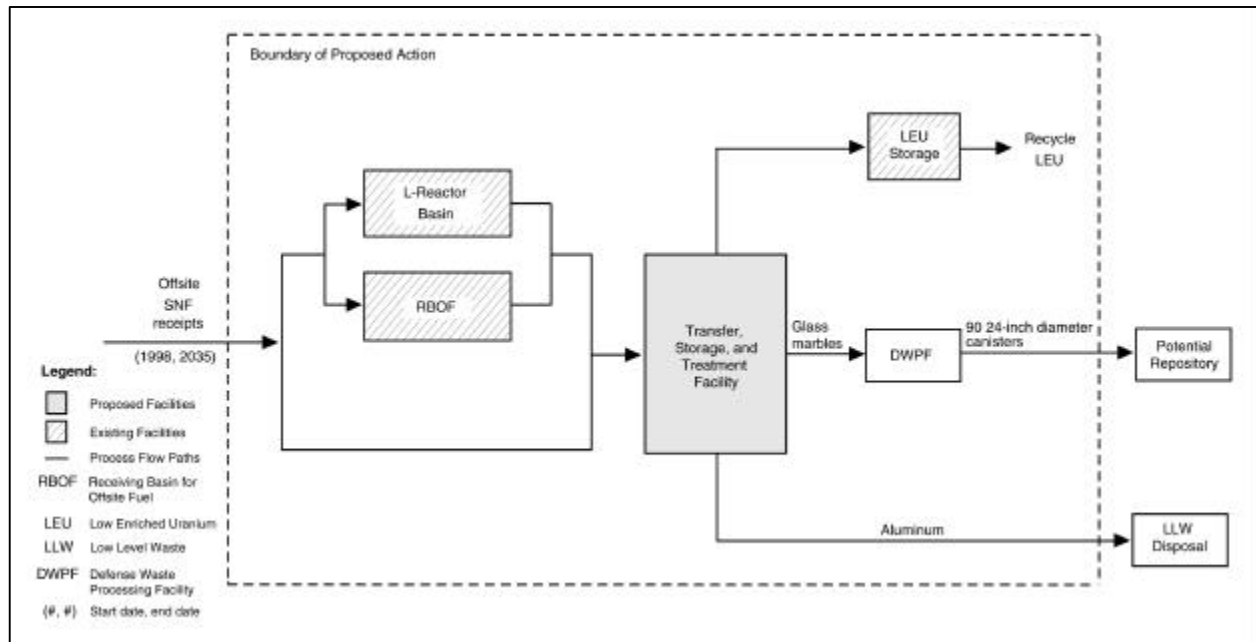


Figure 2-4. New Processing Technology - Electrometallurgical Treatment.

Table 2-2. Applicability of New Processing Technology options.

		Fuel Group	Melt and Dilute	Mechanical Dilution	Vitrification Technologies	Electrometallurgical Treatment
	A.	Uranium and Thorium Metal Fuels	Applies	Does not apply - Mechanical treatment would not address chemical reactivity issue.	Applies	Applies
	B.	Materials Test Reactor-Like Fuels	Applies	Applies	Applies	Applies
	C.	HEU/LEU ^a Oxides and Silicides Requiring Re-sizing	Applies	Applies	Applies	Applies
	D.	Loose Uranium Oxide in Cans	Applies	Does not apply - These fuels are granular and might contain particulates. This technology would leave Group D fuels as particulates. Current understanding of repository acceptance criteria is that particulate fuels would not be accepted without special treatment.	Applies	Applies
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EC	E.	Higher Actinide Targets	This fuel group will be continually wet stored until DOE decides on their final disposition.	This fuel group will be continually wet stored until DOE decides on their final disposition.	This fuel group will be continually wet stored until DOE decides on their final disposition.	This fuel group will be continually wet stored until DOE decides on their final disposition.
	F.	Non-Aluminum-Clad Fuels	Does not apply - Record of Decision for Programmatic SNF EIS ^b designated INEEL ^c as location for non-aluminum SNF management.	Does not apply - Record of Decision for Programmatic SNF EIS designated INEEL as location for non-aluminum SNF management.	Does not apply - Record of Decision for Programmatic SNF EIS designated INEEL as location for non-aluminum SNF management.	Does not apply - Record of Decision for Programmatic SNF EIS designated INEEL as location for non-aluminum SNF management.
<p>a. HEU/LEU = highly enriched uranium/low enriched uranium.</p> <p>b. DOE (1995b).</p> <p>c. INEEL = Idaho National Engineering and Environmental Laboratory.</p>						

Table 2-3. Comparison of preferred and backup technologies for aluminum-SNF disposal.

Technology	Advantages	Disadvantages
Preferred technology: Melt-Dilute Process	<ul style="list-style-type: none"> • U-235 enrichment readily adjusted by dilution with depleted uranium to meet proliferation policy and nuclear criticality constraints. • Melting reduces the volume of the fuel (see Section A.2.1). DOE estimates about 400 canisters would be generated, in comparison to about 1,400 canisters for Direct Co-Disposal. • Homogenous melt product provides basis for predictable behavior in geologic repository. 	<ul style="list-style-type: none"> • Implementation requires high temperature operation of melter and offgas control equipment in shielded cell.
Backup technology: Direct Co-Disposal Process	<ul style="list-style-type: none"> • Process technically straightforward to implement. Shielded-cell handling procedures well developed. • Meets non-proliferation policy criteria better than other alternatives. 	<ul style="list-style-type: none"> • Different SNF configurations, materials, and U-235 enrichments present packaging complexities. • No adjustment of U-235 enrichment possible to meet criticality constraints in a geologic repository. May require the use of exotic nuclear poisons. • No reduction in the volume of the fuel. • Non-uniform SNF structures and compositions complicates documentation of fuel characteristics to meet repository waste acceptance criteria and to predict behavior in a geologic repository.

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potential for criticality. The canisters would be filled with an inert gas, welded closed, and placed in dry storage to await shipment to the geologic repository.

The fission products would remain with the uranium-aluminum alloy, making their release difficult. However, mechanical dilution would not be as effective from a nuclear nonproliferation viewpoint as other treatments (such as Melt and Dilute) because of the potential to separate the pressed or chopped depleted uranium and SNF. The dilution process and the addition of a neutron poison would decrease criticality potential. The solid form with low enrichment could be acceptable at the geologic repository. Although hydrogen generation in the canister would be possible due to the radiolysis of bound water, DOE could minimize hydrogen buildup by eliminating water from the canisters (e.g., by vacuum drying).

2.2.4.3 Vitrification Technologies

DOE could use one of three vitrification technologies: (1) Dissolve and Vitrify, (2) Glass Material Oxidation Dissolution System, or (3) Plasma Arc Treatment. In the vitrification options, the SNF would be converted to oxide and dissolved in molten glass to form a vitrified product. These options have the advantage of producing a vitrified waste form similar to that used for the disposal of high-level waste. Therefore, they should qualify for acceptance at a geologic repository. The final form would contain fission products, and criticality and nonproliferation concerns would be addressed by the dilution of enriched uranium.

For these options, DOE would crop and cold-vacuum-dry SNF in the Transfer, Storage, and Treatment Facility and either place the fuel in canisters for dry storage pending treatment or send it immediately for treatment. The resulting glass or ceramic would be poured into 24- by

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120-inch (61- by 305-centimeter) canisters and placed in dry storage. The use of 24-inch diameter canisters would enable disposal like vitrified high-level waste.

These are advanced technologies. As such, they introduce more technical and schedule risk than the other options in this alternative. This EIS analyzes the impacts of the Dissolve and Vitrify option as representative of all three because DOE believes that the impacts among the three would be similar. The following paragraphs describe the three vitrification technologies; Appendix A provides more information.

Dissolve and Vitrify

The Dissolve and Vitrify treatment is similar to conventional processing except there would be no recovery of enriched uranium. The SNF would be cropped and charged to an electrolytic dissolver. The electrolyte solution would be nitric acid saturated with boric acid. If necessary, depleted uranium would be added to produce low-enriched uranium. The entire solution, including uranium and fission products, would be vitrified. The process would operate in a batch mode to ensure criticality control.

This EIS analyzes performing the Dissolve and Vitrify option in the Transfer, Storage, and Treatment Facility; however, DOE could modify one of the canyons to perform the process. DOE is not considering vitrification of this material in DWPF because that process is not designed to accommodate more than trace quantities of fissile material without major modifications that would be impractical and incompatible with DWPF operations, schedules, and mission.

Glass Material Oxidation and Dissolution System

The Glass Material Oxidation and Dissolution System would convert SNF directly to borosilicate glass using a batch process. The final form would address criticality concerns by diluting the uranium-235 with depleted uranium and by using

boron oxide as a dissolving agent (boron is a neutron poison).

The process would use lead dioxide to oxidize the metals in the SNF so they would be soluble in glass. The resulting lead metal would be recovered and oxidized for reuse. The product of the process would be glass marbles that a second stage of melting could consolidate into logs. The process would occur in the new Transfer, Storage, and Treatment Facility.

Plasma Arc Treatment

The Plasma Arc Treatment technology would use a plasma torch to melt and oxidize the SNF in a rotating furnace. The fuel would be fed into the process with minimal sizing or pretreatment. The plasma torch would heat the fuel to temperatures as high as 2,900°F (1,600°C). The rotation of the furnace and the pressure of the torch would mix the melted fuel. A ceramic binder such as contaminated soil would be added to the mixture to form a glass-ceramic. Depleted uranium could be added to the process to produce low-enriched uranium. When the melting and oxidation is complete, the furnace rotation would slow and the molten fuel would flow by gravity into molds. The process would be conducted in the Transfer, Storage, and Treatment Facility, which would be equipped to capture volatile and semivolatile off-gasses.

2.2.4.4 Electrometallurgical Treatment

Under the Electrometallurgical Treatment option, DOE would crop and cold-vacuum-dry the SNF in the Transfer, Storage, and Treatment Facility, can it, and either place it in dry storage pending treatment or send it immediately to the treatment phase, which would shred and melt it into metal ingots. An ingot would be placed in an electrorefiner, where most of the metal in the SNF (aluminum) would be removed as a low-level waste stream. The remaining metal would be placed in a second electrorefiner where the uranium would be removed. If necessary, the uranium would be fed to a melter where depleted uranium would be added to produce low-enriched uranium. The

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uranium could be sold as recycled uranium for manufacture into commercial nuclear fuel. The remainder of the fuel materials would be oxidized in a furnace and dissolved in glass which would be poured into 24- by 120-inch (61- by 305-centimeter) canisters and placed into dry storage.

This option has the advantage of potentially recycling the enriched uranium. Criticality concerns would be addressed by the isotope dilution of the highly enriched uranium, eliminating the issue of SNF acceptance at a geologic repository. DOE has been developing the electrometallurgical treatment process for certain non-aluminum-based SNF.

Figure 2-4 shows the Electrometallurgical Treatment technology. Appendix A provides a more complete discussion of the technology.

2.2.5 CONVENTIONAL PROCESSING TECHNOLOGY

In this technology, DOE would process SNF in the F or H Area Canyon directly from wet storage. The Record of Decision for the Final EIS on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (61 FR 25091) stated that fuel would be processed in F Canyon. Because F Canyon is scheduled to be shut down before all the fuel could be processed, and because F Canyon is not suitable for highly-enriched uranium processing without modifications, H Canyon also would be used. The process would chemically dissolve the fuel and separate fission products from the uranium by solvent extraction. The uranium would be blended with depleted uranium, as necessary, to bring the enrichment down to about 5 percent or less. The wastes from solvent extraction would contain the highly radioactive fission products, thorium, and possibly some uranium. This high-level waste would be separated into high- and low-activity fractions, which would be converted to glass (vitrified) in DWPF and to a cementitious low-level solid in the Saltstone Manufacturing and Disposal Facility, respectively. Recovered uranium could be sold to a

commercial producer of nuclear fuel. DOE would dispose of the vitrified waste in a geologic repository and the saltstone in onsite vaults.

For Conventional Processing, DOE would use several existing SRS facilities:

- The L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuel for interim storage of the SNF before processing
- The F and H Canyons and related facilities for processing
- The high-level waste tank farms, DWPF, and Saltstone Manufacturing and Disposal Facility for high-level waste disposition

DOE expects that the Experimental Breeder Reactor-II fuel and the Mark-42 targets would be processed in F Canyon. The operation would result in the separation of plutonium that would be converted to metal in FB-Line and then placed in storage at SRS pending disposition in accordance with decisions reached under the *Surplus Plutonium Storage and Disposition EIS* currently being prepared by DOE. This material would not be used in any military application. All other processing operations would be conducted in H Canyon. Processing operations in H Canyon would continue if all fuel were to be processed until the aluminum-based SNF inventory was eliminated and the SNF receipt rate was low in about 2009 (i.e., receipts would be about 150 Materials Test Reactor-like elements per year and 12 High Flux Isotope Reactor assemblies per year). In parallel with processing operations, DOE could construct a Transfer, Storage, and Treatment Facility to receive and treat new SNF after processing operations cease. Because of the small volume of SNF to be processed in this facility, its dry storage capacity would be much less than required for other technologies.

Conventional Processing would be applicable to all fuel groups except most of the higher actinide targets (specifically the Mark-51 and "other" targets) and the non-aluminum-clad fuels. Con-

ventional Processing would apply to the Mark-18s in the Higher Actinide Targets fuel group. The Record of Decision for the Programmatic SNF EIS (DOE 1995b) designated the Idaho National Engineering and Environmental Laboratory as the location for management of non-aluminum-clad SNF. The SRS would store these fuels pending shipment to the Idaho National Engineering and Environmental Laboratory.

The resulting low-enriched uranium would not be suitable for use in weapons and any plutonium separated from the Experimental Breeder Reactor-II fuel or Mark-42 targets would be part of the plutonium considered surplus to the nuclear weapons program that will be dispositioned through decisions reached under the plutonium disposition EIS. Repository acceptance criteria should not be an issue because the vitrified high-level waste would be the same as the vitrified waste DOE is currently producing at SRS, and DOE has a high level of confidence that vitrified waste will meet the repository acceptance criteria. This option would add to the inventory of waste stored at SRS. However, sufficient storage and DWPF capacity exist to accommodate the added volume.

Figure 2-5 shows the Conventional Processing option. Appendix A provides more information on the technology.

2.3 Spent Nuclear Fuel Management Facilities

The implementation of the proposed action would require the construction of a Transfer and Storage Facility or a Transfer, Storage, and Treatment Facility and the use of several existing facilities, depending on the alternative selected. Table 2-4 lists the facilities required for the technologies. The following sections describe the existing and new facilities.

2.3.1 EXISTING FACILITIES

The existing SRS facilities that DOE would need for the proposed action are the L-Reactor Facility, the Receiving Basin for Offsite Fuel, and the

F and H Canyons. Figure 2-6 shows the locations of these facilities. Appendix B provides information on the status of identified vulnerabilities at these facilities.

2.3.1.1 L-Reactor Facility

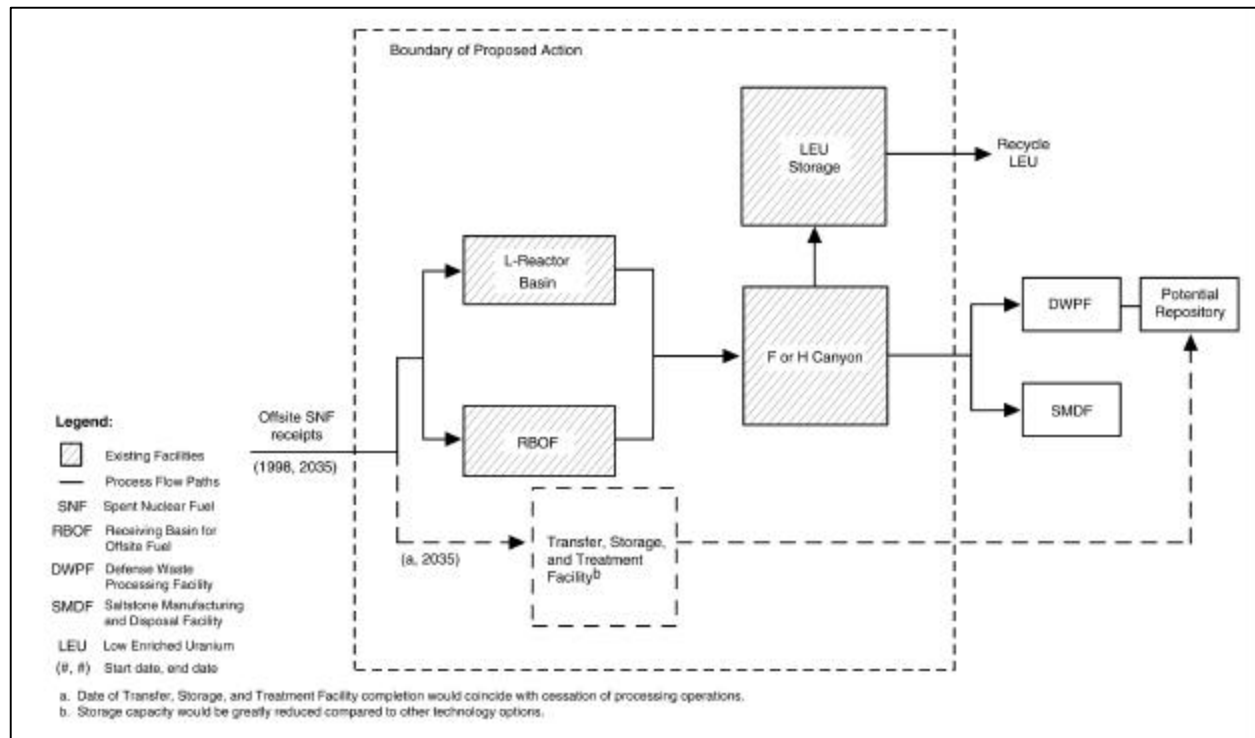
Facility Description

The Federal Government built L Reactor in the early 1950s to produce nuclear materials for national defense. In 1988 DOE shut the reactor down for safety upgrades, and has not restarted it. In 1993 the Department ended the reactor's materials production mission. The current mission of this facility is to store reactor components and other radioactive materials in the disassembly basin, receive and store foreign and domestic research reactor fuel in the disassembly basin, decontaminate shipping casks in the stack area, store contaminated moderator in tanks or drums, and compact low-level waste in a compactor. DOE maintains the structures, systems, and components necessary to perform these missions, but has deenergized, drained, or otherwise deactivated many others.

In addition to the support systems, L Reactor has three principal areas that could be important to the proposed action – the disassembly basin, the L-Reactor building, and the stack area. Figure 2-7 shows L-Reactor and indicates the locations of these areas.

The disassembly basin, which would be the principal structure supporting the SNF storage mission, is a large concrete basin containing approximately 3.4 million gallons (13,000 cubic meters) of water varying in depth from 17 to 50 feet (5.2 to 15 meters). DOE has upgraded the basin to improve water control and monitoring, including continuously operating deionizers to improve water chemistry, makeup water deionizers, and a water level monitoring system. In addition, DOE has added storage racks to accommodate anticipated fuel receipts. The disassembly basin contains a transfer bay with one water-filled pit and heavy lifting equipment to transfer shipping casks to the basin.

The L-Reactor building has space potentially suitable for installation of facilities for treatment of SNF (see Section 2.3.2.2). The space includes the process room and crane maintenance area. The process room, a shielded area situated

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TC**Figure 2-5.** Conventional Processing.**Table 2-4.** Facilities needed for SNF technologies.

Technology	Receiving Basin for Offsite Fuel	L-Reactor Facility	F or H Canyon	Transfer and Storage Facility	Melt and Dilute Treatment Facility	Mechanical Dilution Treatment Facility	Vitrification Facility	Electrometallurgical Treatment Facility	Renovated Reactor Facility
1. Prepare for Direct Disposal/Direct Co-Disposal	✓	✓		✓					✓
2. Repackage and Prepare to Ship ^a	✓	✓ ^b		✓					✓
3. Melt and Dilute	✓	✓		✓	✓				✓
4. Mechanical Dilution	✓	✓		✓		✓			✓
5. Vitrification Technologies	✓	✓		✓			✓		✓
6. Electrometallurgical Treatment	✓	✓		✓				✓	✓
7. Conventional Processing	✓	✓	✓	✓	✓ ^c				
8. Continued Wet Storage	✓	✓							

a. To another DOE site.
b. Needed only if a Transfer, Storage, and Treatment Facility were implemented in a reactor facility.
c. Once conventional processing is terminated, the remaining SNF would require treatment using one of the new technologies. A Melt and Dilute Treatment Facility is included as part of Conventional Processing as a reference follow-on treatment

above the reactor tank, formerly provided access to the reactor by means of a charge and discharge machine for handling reactor fuel assemblies. The area is serviced by an overhead crane. Fuel assemblies were transferred from the L-Reactor Disassembly Basin to the process room by way of an interconnecting water canal. The crane maintenance area, connected to the process room by a shielded crane wash area, allowed hands-on maintenance of the fuel assembly transfer systems.

DOE uses the L-Reactor stack area to unload shipping casks from their International Organization for Standardization (ISO) containers and to decontaminate empty shipping casks. The decontamination hut has a sump pump, spray equipment, a ventilation system, and deionizers.

In 1993 DOE performed a vulnerability assessment of its SNF facilities and identified several vulnerabilities related to the disassembly basins (DOE 1993). The Defense Nuclear Facilities Safety Board reported other vulnerabilities (DNFSB 1994; Burnfield 1995; Conway 1996), including the lack of adequate water chemistry control, which resulted in the corrosion of stored SNF and some cladding failure. The corroding fuel resulted in a buildup of radionuclides in the water and in the sludge at the bottom of the basins. Another vulnerability was the lack of an adequate leak detection capability. Since the vulnerability assessments, DOE has completed the corrective actions. One of the more significant upgrades is the installation of deionizers for maintaining water quality; maintenance of water chemistry is important to minimize corrosion. Appendix B describes these vulnerabilities and corrective action plans in greater detail.

Facility Operations

DOE would receive SNF in shipping casks designed to meet SNF cask design criteria (10 CFR 71). If the cask was too large for the L-Reactor Disassembly Basin or if other operational restrictions (such as a maintenance out-age) occurred, DOE would transport the cask to the Receiving Basin for Offsite Fuel in H Area, re-

move the fuel and place it in a smaller cask, and transfer it to L Reactor. The smaller casks would be moved to the transfer bay of the disassembly basin.

SNF is unloaded from the casks underwater. The procedure is as follows: the casks are vented, filled with water, and submerged in the transfer bay. The purged air is cleaned by high-efficiency particulate air filters before being discharged to the atmosphere. The casks are opened and the fuel elements placed in a bucket for examination. If the fuel cannot be identified or is inconsistent with the documentation provided by the reactor operator, it is isolated until the discrepancy is resolved.

The SNF is moved to the storage area of the disassembly basin through a transfer canal. The cask lid is replaced and the cask is drained, washed, and decontaminated. Decontamination water is sent to the disassembly basin.

2.3.1.2 Receiving Basin for Offsite Fuel

Facility Description

The Receiving Basin for Offsite Fuel, located in H Area, has provided storage for irradiated SNF since 1964. It has an unloading basin, two storage basins, a repackaging basin, a disassembly basin, and an inspection basin, all underwater. Fuel is handled or stored under at least 4 feet (1.2 meters) of water to provide shielding against radiation. The reinforced-concrete basins are below grade. They have either chemical coatings or stainless-steel linings for ease of decontamination. The storage lattice in the basins consist of rows of racks of aluminum I-beams. Gratings, guide plates, and spacers between the racks separate individual storage positions and provide the spacing required for criticality safety.

In addition to the water-filled basins, the Receiving Basin for Offsite Fuel has a receiving bay, dry cask inspection pit, control room, office areas, equipment storage areas, and concrete cells that contain tanks for water decontamination (deionization) and temporary storage of

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Figure 2-6. SRS map indicating locations of facilities needed for Proposed Action.

Figure 2-7. Plan view of the L-Reactor facility.

radioactive liquid waste. The facility has a 100-ton (91-metric-ton) bridge crane that travels on rails approximately 31 feet (9 meters) above grade. The crane has two 50-ton (45-metric-ton) hoists and two 3-ton (2.7-metric-ton) hoists. The crane travels over the cask receiving, unloading, and fuel storage areas.

The DOE vulnerability assessment (DOE 1993) and inspections performed by the Defense Nuclear Facilities Safety Board (Burnfield 1995; Conway 1996) identified vulnerabilities related to the Receiving Basin for Offsite Fuel. These vulnerabilities primarily involved the seismic qualification of the building, the lack of adequate leak detection, and the spacing of vertically stored fuel assemblies (a criticality concern). Appendix B describes these vulnerabilities and their corrective actions (which have all been completed).

Facility Operations

The receiving bay on the north side of the Receiving Basin for Offsite Fuel receives shipping casks containing irradiated fuel delivered by truck or rail. Radiological surveys of the casks determine external radiation and surface contamination levels. The cask is vented after cleaning and filled with water that is sampled to detect contamination, which would indicate damaged or failed fuel. The cask lid bolts are loosened and the cask transferred to the cask basin using the 100-ton (91-metric-ton) overhead crane. The cask is lowered into the basin until the top of the lid is approximately 3 feet (1 meter) above the water surface and the lid bolts are removed. The cask is lowered to the bottom of the basin and the lid removed. Fuel elements are removed from the cask and placed in transfer buckets, cans, or bundles, depending on the fuel design. The bucket, can, or bundle is placed in a storage rack and the process repeated until all fuel had been unloaded from the cask.

The Receiving Basin for Offsite Fuel has separate basins to segregate and can damaged or failed fuel, disassemble fuel components by mechanical means (e.g., cutting), or perform inspection and measurement. The basin water

circulates through a filter and a deionizer for purification and clarification. DOE replaces the filters and deionizers periodically, depending on radioactivity or impurity levels in the water.

2.3.1.3 F and H Canyons

Facility Description

Two SRS facilities – F and H Canyons – could chemically separate uranium from fission products in SNF. The canyon facilities are nearly identical and use similar radiochemical processes for the separation and recovery of plutonium, neptunium, and uranium isotopes. Historically, F Canyon recovered plutonium-239 and uranium-238 from irradiated natural or depleted uranium, and H Canyon recovered plutonium-238, neptunium-237, and uranium-235 from irradiated reactor fuels and targets.

The canyons buildings are reinforced-concrete structures, 835 feet (254 meters) long by 122 feet (37 meters) wide by 66 feet (20 meters) high. They house the large equipment (tanks, process vessels, evaporators, etc.) used in the chemical separations processes.

Each canyon facility contains two canyons, the hot canyon and the warm canyon. The two canyons are parallel and separated by a center section, which has four floors. The center section contains office space, the control room for facility operations, chemical feed systems, and support equipment such as ventilation fans. Processing operations involving high radiation levels (dissolution, fission product separation, and high-level radioactive waste evaporation) occur in the hot canyon, which has thick concrete walls to shield people outside and in the center section from radiation. The final steps of the chemical separations process, which generally involve lower radiation levels, occur in the warm canyon. The F and H Canyons are designed to prevent the release of airborne radioactivity. The ventilation systems maintain a negative air pressure with respect to outside pressure. The ventilation discharges are filtered by high-efficiency particulate air filters and sand filters that remove

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more than 99.9 percent of the particulate radioactivity. Figure 2-8 shows a cutaway view of a canyon building. Figure 2-9 is an aerial photograph of H Canyon and the surrounding area.

DOE and the Defense Nuclear Facilities Safety Board have identified environmental, safety, and health vulnerabilities at the F and H Canyons (DOE 1993; DNFSB 1994). These vulnerabilities relate to the seismic qualification of the buildings and the continued storage of in-process nuclear materials. DOE has verified the seismic qualification of the canyons. In accordance with the various Records of Decision for the Interim Management of Nuclear Materials EIS (DOE 1995a), DOE is stabilizing selected materials of concern identified by the Defense Nuclear Facilities Safety Board.

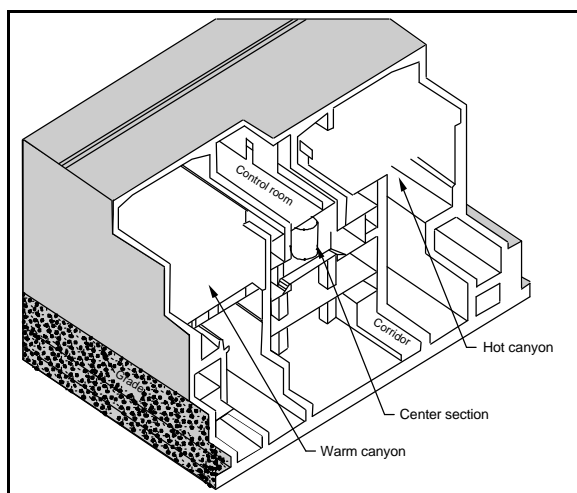


Figure 2-8. Canyon building sections.

Facility Operations

The SNF would arrive by rail in a shielded shipping cask from either the Receiving Basin for Offsite Fuel or the L-Reactor Disassembly Basin. The fuel would be unloaded and placed in an interim storage pool by a remotely operated crane. At the appropriate time, the fuel would be placed in the dissolver and dissolved by nitric acid. If the processing was performed in F Canyon, the acid solution would be blended down with depleted uranium. However, because H Canyon is designed to handle enriched uranium, the blend-

ing to low enriched uranium in H Canyon could occur at virtually any point in the processing operation. In either case, the uranium would be blended to about 5 percent uranium-235.

The resulting acid solution would be chemically processed using clarification and solvent extraction to produce a relatively pure and concentrated stream of uranyl nitrate, which would be stored in tanks awaiting disposition including selling it to commercial reactor fuel users/ manufacturers. Building ventilation discharge would be filtered (including sand filters) to remove at least 99.9 percent of the particulate radioactivity.

2.3.2 Proposed Facilities

DOE could construct new facilities or modify existing ones to accomplish the Proposed Action, depending on the alternative selected.

2.3.2.1 Transfer and Storage Facility

A Transfer and Storage Facility would provide remote handling and heavy lifting capability, hot cells, and space to receive SNF shipments. This facility would place SNF in interim storage as needed, open the shipping containers, sample and analyze the fuel, crop end fittings if necessary, vacuum-dry the SNF, repack the fuel in storage canisters, and place the repackaged fuel in interim storage. DOE would use this facility to perform the functions listed in Table 2-5 without the use of water-filled storage pools; however, DOE could choose to provide the capability to receive incoming SNF in a wet basin. This small wet basin, if used, would be for receipt only - not storage. Figure 2-10 shows this facility.

The dry storage segment of the facility would provide lag storage for SNF waiting for preconditioning or treatment, road-ready storage for fuel packaged for shipment to a geologic repository, and temporary storage for empty canisters and loaded and unloaded transportation casks. The size of the storage facility would depend on how DOE decided to implement the Proposed Action. For example, if DOE

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Figure 2-9. H Canyon and surrounding area
(view toward northeast).

Table 2-5. Transfer and Storage Facility functions.

Function	Description
Receiving/shipping	Receive casks, unload SNF, load casks, and prepare loaded and unloaded casks for shipment
Characterization	Inspect SNF for storage, conditioning, and disposition (e.g., visual inspection, gamma spectrometry, and calorimetry)
Conditioning	Crop end fittings or binding pins; activity would not breach cladding or modify the fuel matrix
Packaging	Place SNF in appropriate cans and canisters (e.g., vacuum drying, filling with inert gas) and packaging for road-ready storage or direct transport
Stability/verification testing	Provide analytical capabilities to perform sampling and analysis to verify conformance to repository waste acceptance criteria
Treatment Facility Interface	Provide interfaces necessary to accommodate various treatment technologies
Storage	Provide dry road-ready storage using modular design and construction

Figure 2-10. Schematic cut-away of the transfer storage and treatment facility.

selected Electrometallurgical Treatment as a new processing technology, the storage component of the facility would only need to provide lag storage for fuel awaiting treatment; no road-ready storage would be necessary because waste produced from the Electrometallurgical Treatment would be sent to DWPF. Table 2-6 lists the number of road-ready canisters DOE would need to store for each technology. In each case, the number of canisters for the treatment technologies is less than that for the Direct Co-Disposal technology. The size of the transfer operations component of the facility would be independent of any new technology selected. In the event Conventional Processing is implemented, the size of the Transfer and Storage Facility would be reduced by about 30 to 60 percent.

The storage segment probably would have one of the three generic designs shown in Figure 2-11. Regarding the environmental impacts of constructing and operating a dry storage facility, the

Foreign Research Reactor Spent Nuclear Fuel EIS (DOE 1996c) concluded, "There are significant differences between these technologies in terms of construction, operations and maintenance costs and various design details. However, these differences do not result in any important variations in environmental impacts and consequences."

The modular dry storage vault design is a self-contained concrete structure that would provide storage for hundreds of SNF assemblies. The vault would contain a charge and discharge bay with an SNF-handling machine above a floor containing steel tubes to house the removable fuel canisters. The bay would be shielded from the stored fuel by the thick concrete floor and shield plugs inserted at the top of the steel storage tubes. Large labyrinth air supply ducts and discharge chimneys would permit natural convection cooling of the fuel storage tubes to dissipate decay heat. The perimeter concrete walls would provide shielding.

Table 2-6. Road-ready storage capacities.

Technology	Number of co-disposal canisters (17-inch diameter)
Prepare for Direct Co-Disposal/Direct Disposal	1,400 ^a
Repackage and Prepare to Ship	0
Melt and Dilute	400
Mechanical Dilution	630
Vitrification Technologies	1,350 ^b
Electrometallurgical Treatment	0 ^c
Conventional Processing	0 ^d
Continued Wet Storage	0

- a. Direct Disposal in 24-inch diameter canisters would require 1,100 canisters.
- b. Vitrification Technologies would produce 24-inch diameter canisters. The value reported is for Dissolve and Vitrify and Glass Material Oxidation and Dissolution System. Plasma Arc Treatment would produce 490 24-inch diameter canisters.
- c. Electrometallurgical treatment would produce about 90 high-level waste canisters to be stored in the Glass Waste Storage Building of the Defense Waste Processing Facility.
- d. Conventional Processing would result in storage of about 150 high-level waste canisters in the Glass Waste Storage Building of the Defense Waste Processing Facility.

Figure 2-11. Typical spent nuclear fuel dry storage facilities.

A dry concrete storage cask, either vertical cask-on-pad or a horizontal concrete module, would perform a similar function, but would not be in a vault. The cask would provide the shielding. A dedicated truck and trailer would transport the fuel containers from the transfer area of the facility to the dry storage area. A ram (for horizontal modules) or a crane (for vertical modules) would insert the fuel package into the storage cask. Appendix F of the *Foreign Research Reactor Spent Nuclear Fuel EIS* (DOE 1996c) contains more information on dry storage facility designs.

DOE used a formal site selection process (Wike et al. 1996) to identify and evaluate potential sites for the construction of the Transfer and Storage Facility. Among the siting criteria were engineering and operational parameters; infrastructure support; human health, environmental, and ecological impacts; regulatory criteria; and land use planning. The process identified five potential sites, two of which received substantially higher scores than the others. These sites are the east side of L Area inside the facility fence, and the southeast side of C Area inside the facility fence. DOE has determined that these two sites are preferred and has completed some geotechnical evaluations on them. Figures 2-7 and 2-12, respectively, show these locations. DOE has considered these two sites in the analyses in this EIS. The transfer functions performed by a Transfer and Storage Facility could also be located in a renovated reactor building. Storage facilities would be as described above.

2.3.2.2 Transfer, Storage, and Treatment Facility

DOE could build a new Transfer, Storage, and Treatment Facility in the locations previously described for the Transfer and Storage Facility. Alternatively, the facility could be located in a new facility in F or H Area (Figures 2-13 and 2-14) to take advantage of existing services and infrastructure in these areas. DOE would con-

struct this facility only if it selected a technology that required it. The facility would be similar to the Transfer and Storage Facility described in Section 2.3.2.1, but with the addition of SNF treatment capability as described in the following paragraphs. The operations performed in the facility would depend on the treatment technology DOE selected, and could include Melt and Dilute, Mechanical Dilution, Vitrification Technologies, or Electrometallurgical Treatment.

The facility design would address criticality issues during normal operations and under conditions of extreme natural phenomena. The facility would contain hot cells, remote handling equipment for the fuel and canisters, processing equipment such as melters (depending on the technology option selected), waste handling and treatment capability, canister decontamination capability, and infrastructure needed for radiological protection operations (e.g., monitoring equipment and protective clothing change rooms). Treatment and handling operations would be performed in facility areas especially designed to prevent the release of airborne radioactivity. For example, the ventilation system would maintain a negative air pressure with respect to outside pressure. The ventilation discharge would be filtered to remove at least 99.9 percent of the particulate radioactivity.

DOE also is considering performing SNF treatments in a renovated reactor facility. In this EIS, DOE has evaluated modifying Building 105-L, and DOE considers this evaluation representative of other reactor area facilities. The processes for transfer and treatment would be located within the L-Reactor building (Figure 2-7), supported by capabilities in the existing structure and adjacent L-Area enclosure. The treatment facilities would be operated in close conjunction with the underwater storage of the SNF in the L-Reactor Disassembly Basin, converting the SNF to the final waste form for dry storage in a Storage Facility as described in Section 2.3.2.1.

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Figure 2-12. Plan view of C-Reactor facility.

Figure 2-13. Potential Transfer, Storage, and Treatment Facility location in F Area.

Figure 2-14. Potential Transfer, Storage, and Treatment Facility location in H Area.

Table 2-7. Fuel groups and technology options that could be applied to meet the purpose and need. For each fuel group, the technologies that would produce the lowest and highest impacts have been identified.

Fuel group	1. Prepare for Direct Co-Disposal	2. Repackage and Prepare to Ship ^a	3. Melt and Di- lute	4. Mechanical Dilution	5. Vitrification Technologies	6. Electro- metallurgical Treatment	7. Conventional Processing
A. Uranium and Thorium Metal Fuels	Yes ^b , LB ^c	No	Yes	No	Yes	Yes	Yes, UB ^d
B. Materials Test Reactor-Like Fuels	Yes, LB	No	Yes	Yes	Yes	Yes	Yes, UB
C. HEU/LEU ^e Oxides and Silicides Requiring Resizing or Special Packaging	Yes, LB	No	Yes	Yes	Yes	Yes	Yes, UB
D. Loose Uranium Oxide in Cans	No	No	Yes, LB	No	Yes	Yes	Yes, UB
E. Higher Actinide Targets ^f	NA	Yes, LB/UB	NA	NA	NA	NA	NA
F. Non-Aluminum Clad Fuels ^f	NA	Yes, LB/UB	NA	NA	NA	NA	NA

a. This alternative describes repackaging for storage at SRS pending shipment offsite.

b. "Yes" indicates that the technology can be applied to the fuel group. "No" indicates that the technology cannot be applied to the fuel group.

c. LB = lower bound of impacts.

d. UB = upper bound of impacts.

e. HEU = highly enriched uranium; LEU = low enriched uranium.

TC f. NA = not applicable; not decided in this EIS. Higher actinide targets would be stored until DOE determined their disposition and non-aluminum clad fuel is scheduled to be shipped to Idaho National Engineering and Environmental Laboratory for treatment. Only the impacts of storing these materials are considered in this EIS.

2.4 Alternatives Evaluated

As indicated in Sections 2.2.1 through 2.2.3, none of the technologies is likely to be applicable to all the fuel groups. Table 2-7 lists the technology options DOE believes are applicable to the fuel groups discussed in this EIS. DOE probably would implement a combination of options to accomplish SNF management at SRS. Many (more than 700) technology-fuel group configurations can be created using the information in Table 2-7. Tables 2-1 and 2-2 summarize the basis for the applicability of the New Packaging options and the New Processing Technology options. Conventional Processing could be applied to any fuel group except the non-aluminum-clad fuels and the higher actinide targets. Although the No-Action Alternative could be applied to all fuel groups, it would not meet the purpose and need for action.

Taking into consideration the technology options available to the various fuel groups and decisions previously made about managing certain types of SNF, DOE developed five alternatives to analyze in this EIS. DOE has chosen to present impacts from the No Action Alternative, the Preferred Alternative, the Direct Disposal Alternative, and the Maximum- and Minimum-Impact Alternatives described below to illustrate the range of impacts that could occur from any configuration the decisionmakers might select (Table 2-8). These configurations are representative of the range of those DOE could select to accomplish the proposed action and are expected to include the upper and lower bounds of potential impacts. The No Action Alternative represents the impact from current operations.

DOE recognizes that a combination of technology options might not result in the lowest or highest impact for all evaluated technical parameters (e.g., for a particular configuration, worker health and public health impacts could be lowest, but radioactive waste generation could be highest) and that there are other reasonable alternative configurations that would result in similar minimal or substantial impacts. Impacts resulting in human health effects and environmental

pollution received greater weight than those resulting in the consumption of natural resources or waste disposal space. In addition, impacts to the general public received greater weight than those to SRS workers. Similarly, impacts that would occur immediately (e.g., operation of new and existing processing facilities) received greater weight than impacts that are not expected but could occur in the distant future.

2.4.1 MINIMUM IMPACT ALTERNATIVE

This alternative consists of the fuel groups and technologies that DOE believes would result in the lowest overall impact. The identification of the minimum impact (and environmentally preferred) alternative required both quantitative and qualitative analyses. The first step tabulated the analytical parameters (e.g., volume of high-level waste, air concentrations) and the minimum-impact technology for each parameter for each fuel group. The selected analysis parameters often resulted in a combination of high and low impacts for a particular fuel group. Therefore, the second step required a qualitative examination of trends in combinations that would provide overall minimum impacts.

DOE believes that the range of impacts from other reasonable choices of the minimum-impact alternative would be small. Therefore, DOE expects that the impacts of this alternative would be representative of the lower bound of impacts from the Proposed Action.

The minimum impact alternative would include New Packaging and New Processing Technologies options. Material Test Reactor-like fuels and highly enriched uranium/low enriched uranium (HEU/LEU) oxides and silicides would be treated using the Direct Disposal/Direct Co-Disposal option and placed in the Transfer and Storage Facility with a minimum of treatment (e.g., cold-vacuum drying and canning). The uranium and thorium metal fuels would be treated using the Direct Disposal/Direct Co-Disposal option but more rigorous treatment (i.e., hot-vacuum drying) would be required.

Table 2-8. Alternatives analyzed in this EIS.

	Fuel Group	No-Action Alternative	Minimum Impact Alternative	Direct Disposal Al- ternative	Preferred Alter- native	Maximum Impact Alternative
TC	A. Uranium and Thorium Metal Fuels	Continued Wet Storage	Prepare for Direct Co-Disposal	Conventional Proc- essing	Conventional Processing	Conventional Proc- essing
	B. Materials Test Reactor-like Fuels	Continued Wet Storage	Prepare for Direct Co-Disposal	Prepare for Direct Co-Disposal	Melt and Dilute	Conventional Proc- essing
	C. HEU/LEU Oxide and Sili- cides Requiring Resizing or Special Packaging	Continued Wet Storage	Prepare for Direct Co-Disposal	Prepare for Direct ^a Co-Disposal	Melt and Dilute ^a	Conventional Proc- essing
	D. Loose Uranium Oxide in Cans	Continued Wet Storage	Melt and Dilute	Melt and Dilute ^b	Melt and Dilute ^b	Conventional Proc- essing
	E. Higher Actinide Targets	Continued Wet Storage	Repackage and Pre- pare to Ship to An- other DOE Site	Repackage and Pre- pare to Ship to An- other DOE Site ^c	Continued Wet Storage	Repackage and Pre- pare to Ship to An- other DOE Site ^c
	F. Non-Aluminum-Clad Fu- els	Continued Wet Storage	Repackage and Pre- pare to Ship to An- other DOE Site	Repackage and Pre- pare to Ship to An- other DOE Site	Repackage and Prepare to Ship to Another DOE Site	Repackage and Pre- pare to Ship to An- other DOE Site
TC	a. Conventional processing would be the preferred technology for the failed or sectioned Oak Ridge Reactor fuel, High Flux Isotope Reactor fuel, Tower Shielding Reactor fuel, Heavy Water Components Test Reactor fuel, and a Mark-14 target.					
	b. Conventional processing is the preferred technology for the Sterling Forest Oxide fuel.					
	c. Conventional processing is the applicable technology for the Mark-18 target assemblies (approximately 1 kilogram heavy metal), under these two al- ternatives.					

(DOE notes there is a high degree of technical uncertainty regarding the acceptability of this material in a repository; however, Direct Co-Disposal was postulated to represent minimum impacts.)

TC

DOE would continue to wet store the Mark-51 and other Higher Actinide Targets at the SRS. Additionally, DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event the non-aluminum clad fuel have not been transferred offsite by the time a dry storage facility is in operation at the SRS (to support the Melt and Dilute Technology), DOE could repackage the fuel and transfer the material to dry storage. To maintain operational flexibility, DOE could transfer the Mark-51 and other targets to dry storage. DOE would maintain the Mark-18 targets in wet storage pending disposition decisions due to potential health and safety concerns associated with the actions that would be required to repackage the Mark-18 target assemblies.

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While in wet storage, if fuel began to deteriorate, resulting in imminent environmental, safety, and health vulnerabilities, DOE would use the canyons, if they were operating, to stabilize the vulnerable materials.

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The loose uranium oxide in cans would not be contained in a tightly bound matrix and, therefore, may not be acceptable for placement in a geologic repository. Therefore, the Melt and Dilute technology would be used to treat these fuels.

2.4.2 MAXIMUM IMPACT ALTERNATIVE

This alternative provides the upper bound on the range of impacts from potential configurations. It would provide conventional processing for all SNF except the higher actinide targets and the non-aluminum-clad fuels selected for offsite shipment.

DOE expects that the Experimental Breeder Reactor-II and Mark-42 targets from the uranium and thorium metal fuels group would be processed in F Canyon. All other processing operations would be conducted in H Canyon. Processing operations in H Canyon would continue until the aluminum-based SNF inventory was eliminated and the SNF receipt rate was low (i.e., about 150 Materials Test Reactor-like elements per year and 12 High Flux Isotope Reactor assemblies per year; approximately 2009). In parallel with processing operations, DOE could construct a Transfer, Storage, and Treatment Facility with treatment capability to receive and treat new SNF after processing operations cease. Once the Transfer, Storage, and Treatment Facility was completed, processing in the canyons would be phased out.

Analyses of the maximum impact alternative are conservative in that they assume that the entire SNF inventory would be processed in the canyons, which would produce the greatest impacts of all the treatment options. No credit is taken for discontinuing use of the canyons and processing some of the inventory in a new treatment facility.

Although this EIS proposes only to continue to store Mark-18 targets, DOE has included the impacts of processing the Mark-18 targets in the Maximum Impact Alternative. The analysis of impacts is taken from the Final Environmental Impact Statement for Interim Management of Nuclear Materials. The 12-foot long Mark-18 targets would require size reduction for transport or storage in a dry storage facility. The standard method to reduce the size of the Mark-18 targets would be to cut them up under water in an SRS storage basin. The condition of the Mark-18 targets presents a health and safety vulnerability for under water cutting because of the suspected brittle condition of the targets and the uncertainty concerning which portion of the target assemblies contains the americium and curium product and fission products. Because of these concerns a previous DOE assessment (see Section 1.6.2) concluded that the Department should consider processing the Mark-18 targets. Although that

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alternative was not chosen, and the Mark-18 targets are still stored in the Receiving Basin for Offsite Fuel, the analysis was performed and is incorporated as part of the Maximum Impact Alternative in this EIS. Processing the Mark-18 targets would not extend the operating time for the SRS canyons.

Until the Mark-51 and other Higher Actinide Targets are transferred to another site for use, DOE would continue to wet-store the material at the SRS. Additionally, DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event the Mark-51 and "other" targets and non-aluminum clad fuel have not been transferred offsite by the time a dry storage facility is in operation at the SRS, DOE could repackage the targets and the fuel and transfer the material to dry storage. DOE would transfer the targets and non-aluminum clad fuel to dry storage after the material had been relocated from the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of activities to phase out operations in the Receiving Basin for Offsite Fuel by 2007.

2.4.3 PREFERRED ALTERNATIVE

Under the preferred alternative, DOE would implement several of the technologies identified in Section 2.2 to manage spent nuclear fuel at SRS. These technologies are Melt and Dilute, Conventional Processing, and Repackage and Prepare to Ship. Each of these technologies would treat specific groups of spent nuclear fuel, as described below. The technology and fuel group combinations form DOE's Preferred Alternative in this EIS. The configuration of this preferred alternative is identified in Table 2-9. Figure 2-15 provides a flowchart for the Preferred Alternative.

2.4.3.1 Melt And Dilute

DOE has identified the Melt and Dilute process as the preferred method of treating most (about 97 percent by volume or about 32,000 MTRE) of the aluminum-based SNF considered in this EIS.

DOE will continue to pursue a research and development program leading to a demonstration of the technology in FY 2001 using full-size irradiated research reactor spent nuclear fuel assemblies. With a successful demonstration of the technology, DOE expects to have ready a treatment facility to perform production melt and dilute operations in FY 2008. DOE will ensure the continued availability of SRS conventional processing facilities until we have successfully demonstrated implementation of the Melt and Dilute treatment technology.

The fuel proposed for the preferred Melt and Dilute technology includes the Material Test Reactor-like fuel, most of the Loose Uranium Oxide in Cans fuel, and most of the HEU/LEU Oxide and Silicide fuel. Exceptions are the failed and sectioned Oxide and Silicide fuel, about 10 percent of the Loose Uranium Oxide in Cans fuel as described in Section 2.4.3.2, and the Higher Actinide Targets and Non-Aluminum-Clad fuel that would be repackaged and prepared to ship as discussed in Section 2.4.3.3. The Melt and Dilute Technology satisfies DOE's objective and preference, as stated in the Record of Decision for the Nonproliferation Policy and Spent Nuclear Fuel EIS (60 FR 25091), to select a non-chemical separations-based technology to prepare aluminum-based SNF for placement in a geologic repository. Additionally, this new technology provides significant waste reduction (of high-level, low-level, transuranic, etc.) in comparison to conventional chemical processing and is fully compatible with and supportive of the nonproliferation objectives of the United States.

The potential impacts (e.g., worker and public health, waste generation, socioeconomics, etc.) among the new non-separations based technologies were all very similar; however, the Melt and Dilute option was the most efficient in volume reduction and produced the fewest number of SNF canisters. In fact, Melt and Dilute would increase volume reduction by more than 3 to 1 over Direct Disposal/Direct Co-Disposal. The volume reduction is achieved because the melt and dilute process eliminates voids in the fuel elements and in the canisters and fuel

Table 2-9. The fuel group technology configurations that compose the preferred alternative.

Fuel group		1. Prepare for Direct Co-Disposal	2. Repackage and Prepare to Ship ^a	3. Melt and Dilute	4. Mechanical Dilution	5. Vitrification Technologies	6. Electro- metallurgical Treatment	7. Conventional Processing
EC TC	A. Uranium and Thorium Metal Fuels	—	—	—	—	—	—	Preferred
	B. Materials Test Reactor-Like Fuels	—	—	Preferred	—	—	—	—
	C. HEU/LEU ^b Oxides and Silicides Requiring Resizing or Special Packaging	—	—	Preferred	—	—	—	Preferred ^c
	D. Loose Uranium Oxide in Cans	—	—	Preferred	—	—	—	Preferred ^d
	E. Higher Actinide Targets ^e	—	—	—	—	—	—	—
	F. Non-Aluminum Clad Fuels	—	Preferred	—	—	—	—	—
EC TC	a. This alternative describes shipment to a DOE site other than SRS, not to a geologic repository.							
	b. HEU = highly enriched uranium; LEU = low enriched uranium.							
	c. For failed or sectioned Oak Ridge Reactor fuel, High-Flux Isotope Reactor fuel, Tower Shielding Reactor fuel, Heavy Water Components Test Reactor Fuel, and a Mark-14 target (i.e., <1 percent of material in this fuel group).							
	d. For Sterling Forest Oxide fuel (i.e., about 10 percent of the material in this fuel group).							
	e. The preferred alternative is to maintain fuel Group E in continued wet storage until a decision is made on final disposition.							

Figure 2-15. Preferred Alternative Management Flow-Path.

baskets used in the Direct Disposal/Direct Co-Disposal technology. DOE considered Melt and Dilute to be among the most “proven” of the new non-separations-based technologies because DOE has made extensive progress in the development of the melt and dilute process.

The Melt and Dilute technology offers DOE the flexibility to engineer the final waste form to provide a high degree of confidence the material would be acceptable for placement in a geologic repository. Major technical concerns such as fuel characterization, criticality control, and repository performance can be reduced or eliminated by tailoring the chemical and physical form of the final product to meet specific criteria. DOE expects the Melt and Dilute option would be relatively simple to implement and would be less expensive than other similar technology options, although the ongoing technology development initiative will determine the viability of this alternative. The major technical issue for implementing this technology would be the design of an off-gas system to capture volatilized fission products. Preliminary engineering studies indicate that the system could be designed using proven approaches for managing off-gases.

To implement the preferred alternative (Melt and Dilute technology), DOE would construct a melt and dilute facility in the existing 105-L building at SRS and build a dry-storage facility in L Area, near the 105-L building. DOE is proposing to use an existing facility to house the Melt and Dilute process because the existing structure can accommodate the process equipment and systems; the applicable portions of the structure will meet DOE requirements for resistance to natural hazards (e.g., earthquakes); the integral disassembly basin has sufficient capacity for all expected SNF receipts and the current Site inventory; using 105-L avoids the creation of a new radiologically controlled facility that would eventually require decontamination and decommissioning; and DOE has estimated the cost savings versus a new facility to be about \$70 million.

Using the Melt and Dilute technology, DOE would melt aluminum-based SNF and blend down any highly enriched uranium to low enriched uranium using depleted uranium that is currently stored at SRS. The material would be cast as ingots that would be loaded into stainless-steel canisters approximately 10 feet tall and 2 feet (or less) in diameter. The canisters would be placed in dry storage pending shipment to a geologic repository.

During the development of the Melt and Dilute technology, DOE may determine that, for technical, regulatory, or cost reasons, the Melt and Dilute option is no longer viable. As a back-up to Melt and Dilute, DOE would continue to pursue the Direct Co-Disposal option of the New Packaging Technology and would implement this option if Melt and Dilute were no longer feasible or preferred. Direct Co-Disposal has the potential to be the least complicated of the new technologies and DOE believes this option could be implemented in the same timeframe as could the Melt and Dilute option. However, DOE believed there is greater risk in attempting to demonstrate that aluminum-based SNF, packaged according to the Direct Co-Disposal option, would be acceptable in a geologic repository. A comparison of the preferred (Melt and Dilute) and back-up (Direct Co-Disposal) technologies DOE proposes to use to manage most of the aluminum-based SNF at SRS is presented in Table 2-3.

If DOE identifies any imminent health and safety concerns involving any aluminum-based SNF, DOE could use F and H Canyons to stabilize the material of concern prior to the melt and dilute facility becoming operational.

2.4.3.2 Conventional Processing

DOE proposes to use conventional processing to stabilize some materials before a new treatment facility is in place. The rationale for this processing is to avoid the possibility of urgent future actions, including expensive recovery actions that would entail unnecessary radiation exposure to workers, and in one case, to manage a unique waste form (i.e., core filter block).

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TC The total amount proposed for conventional processing is a relatively small volume of aluminum-based SNF at the SRS (about 3 % by volume and 40 % by mass). This material includes the Experimental Breeder Reactor-II fuel, the Sodium Reactor Experiment fuel, the Mark-42 targets and the core filter block from the Uranium and Thorium Metal fuel group; the failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuels and a Mark-14 target from the HEU/LEU Oxides and Silicides fuel group; and the Sterling Forest Oxide (and any other powdered/oxide fuel that may be received at SRS while H Canyon is still in operation) from the Loose Uranium Oxide in Cans fuel group. Although it is possible that a new treatment technology, such as melt and dilute, could be applied to most of these materials, DOE considers timely alleviation of the potential health and safety vulnerabilities to be the most prudent course of action because it would stabilize materials whose forms or types pose a heightened vulnerability to releasing fission products in the basin. Nonetheless, if these materials have not been stabilized before a new treatment technology becomes available, that new technology (melt and dilute) may be used rather than conventional processing.

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and stored in canisters in the Receiving Basin for Offsite Fuel. The declad fuels present a potential health and safety vulnerability. Should their existing storage containers leak, the metal fuel would corrode and release fission products to the water of the storage basin. Once the metal of the fuel is wetted, simply repackaging the fuel in a water-tight container would not arrest the corrosion and, in fact, could exacerbate storage concerns since potentially explosive hydrogen gas would continue to be generated inside the storage canister as the fuel continued to corrode. An instance of water intrusion and subsequent fuel corrosion has already occurred with one Experimental Breeder Reactor-II canister stored in the Receiving Basin for Offsite Fuel. Additionally, several problems

have occurred with other uranium metal fuel in similar storage conditions at SRS (e.g., the Taiwan Research Reactor fuel with failed or missing cladding that was overpacked in canisters and stored in SRS wet basins). DOE addressed these situations by processing the failed or declad fuel in F Canyon to eliminate the health and safety vulnerability.

TC The failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuel, and a sectioned Mark-14 target from the HEU/LEU Oxides and Silicides fuel group also present potential health and safety vulnerabilities. The integrity of these fuels was destroyed for research purposes. Then the material was canned and placed in wet storage at SRS. A breach of or leak in the cans would expose the interior surfaces of the sectioned fuel to water, contaminating the water in the storage basin with radioactivity, and accelerating the corrosion of the fuel.

A potential health and safety vulnerability also exists for the unirradiated Mark-42 targets from the Uranium and Thorium Metal fuel group and the Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans fuel group. Should a breach occur in the cladding on the Mark-42 targets or in the canisters of Sterling Forest Oxide fuel, the particulate nature of the nuclear material in the targets and the Sterling Forest Oxide fuel could lead to dispersion of radioactive material in the water of the Receiving Basin for Offsite Fuel. Therefore, DOE is proposing to take action now to avoid the possibility of urgent future actions, including expensive recovery actions that also would entail unnecessary radiation exposure to workers.

DOE proposes to process the Experimental Breeder Reactor-II fuel and the Mark-42 targets in F Canyon. That fuel contains plutonium, approximately 114 kg of which would be recovered as part of the normal F Canyon chemical separations process and then transferred to FB-Line for conversion to metal. The plutonium metal would be considered surplus to the nation's nuclear

weapons program and would be placed in storage at the SRS pending disposition pursuant to the January 2000 Record of Decision (ROD) for the Surplus Plutonium Disposition Environmental Impact Statement (DOE 1999). The surplus plutonium would be immobilized using the can-in-canister process or fabricated into mixed-oxide (MOX) commercial power reactor fuel at the SRS. DOE has scheduled processing of the Experimental Breeder Reactor-II fuel and the Mark-42 targets in FY00.

DOE proposes to process the Sodium Reactor Experiment fuel, the failed or sectioned fuel from the HEU/LEU Oxides and Silicides fuel group, and the Sterling Forest Oxide fuel in H-Canyon where the highly enriched uranium would be blended down to low enriched uranium and stored pending potential sale as feed-stock for commercial nuclear fuel. DOE would begin processing operations in H Canyon in 2000 and could complete them in about 18 months.

DOE also proposes to process the core filter block from the Uranium and Thorium Metals fuel group. The core filter block is made of depleted uranium but it contains corrosion-resistant metal (e.g., stainless-steel) that would be incompatible with the Melt and Dilute Technology for aluminum-based SNF. The core filter block could be processed in either F Canyon or H Canyon. In either case, the material would become feedstock to blend down highly enriched uranium from either conventional processing or melt and dilute operations.

The processing operations described above in both F and H Canyons would occur when the canyons were being operated to stabilize other nuclear material. It is the preference of the Department of Energy not to utilize conventional reprocessing for reasons other than safety and health. However, the core filter block is not compatible with the melt and dilute process for aluminum-based SNF. The benefit to develop a new process to accommodate this form would be disproportionately small when compared to the

cost (DOE 1998a). Consequently, the Department proposes an exception in this case.

2.4.3.3 Repackaging

DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event that the non-aluminum-clad fuel has not been transferred offsite by the time a dry storage facility is in operation at the SRS (to support the Melt and Dilute Technology), DOE could repackage the fuel and transfer the material to dry storage.

2.4.3.4 Continued Wet Storage

DOE is not proposing any actions that would lead to the programmatic use of the higher actinide targets. Therefore, under the preferred alternative the Mark-18, Mark-51 and other higher actinide targets would be maintained in wet-storage until decisions are made on their final disposition.

2.4.4 DIRECT DISPOSAL ALTERNATIVE

This alternative combines the New Packaging and the New Processing Technologies with the Conventional Processing Technology. Materials Test Reactor-like fuels and HEU/LEU Oxides and Silicides (except the failed and sectioned fuels) would be treated using the Direct Disposal/Direct Co-Disposal technology and placed in the Transfer and Storage Facility with a minimum of treatment (e.g., cold-vacuum drying and canning).

DOE would manage the Higher Actinide Targets and the non-aluminum based SNF as described in the Maximum Impact Alternative.

The uranium fuel and thorium metal fuel, Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans fuel group, and failed and sectioned fuel from the HEU/LEU Oxides and Silicides fuel group would be treated using chemical separations processes under the Conventional Processing Alternative to alleviate the potential

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health and safety vulnerabilities discussed in Section 2.4.3.2 and because this material probably would not be suitable for placement in a geologic repository if treated with the Direct Disposal/Co-Disposal option. Most of the material in the Loose Uranium Oxide in Cans fuel group would be treated using Melt and Dilute since that material could be received after a melt and dilute facility was available.

2.4.5 NO-ACTION ALTERNATIVE: CONTINUED WET STORAGE

Under the No-Action Alternative, DOE would consolidate existing inventories of SNF at SRS in the L-Reactor Disassembly Basin and the Receiving Basin for Offsite Fuel, and would store incoming SNF shipments in those basins. Maintenance, monitoring, and normal basin operations (as described in Section 2.3.1) would continue. DOE would be able to meet its commitments to receive SNF from domestic, foreign, and university research reactors and from the Idaho National Engineering and Environmental Laboratory. However, DOE would not meet the commitment made in the Record of Decision (61 FR 25092) for the Final EIS on a Proposed Nuclear Weapons Nonproliferation Policy Con-

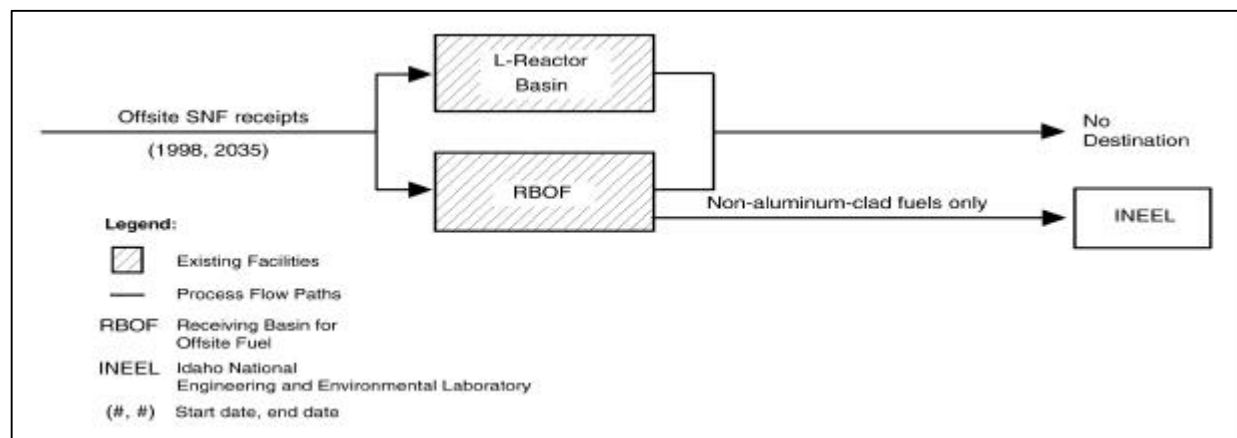
cerning Foreign Research Reactor Spent Nuclear Fuel (DOE 1996c) to manage its SNF in a road-ready condition for ultimate shipment to the geologic repository. DOE could ship non-aluminum-clad fuels to the Idaho National Engineering and Environmental Laboratory in accordance with the Record of Decision (60 FR 28680) for the Programmatic SNF EIS (DOE resulting in increased environmental, safety, and health vulnerabilities. DOE would use the F or 1995b). Over the potentially 40 years of continued wet storage, some fuel could deteriorate, H Canyon facilities if they were operating for other reasons to stabilize any SNF that presented an environmental, safety, or health vulnerability. Figure 2-16 shows the No-Action Alternative.

DOE analyzed the impacts of transporting aluminum-based spent nuclear fuel to the Savannah River Site in the Nonproliferation Policy and Spent Nuclear Fuel EIS (DOE 1996c) and the programmatic SNF EIS (DOE 1995b). These documents concluded that the potential human health impacts from transportation of this fuel to SRS were low.

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Figure 2-16. No-Action Alternative – Continued Wet Storage.



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TC | The No-Action Alternative would be applicable to all fuel groups; however, non-aluminum-clad fuels would remain in wet storage at SRS only until DOE shipped them to the Idaho National Engineering and Environmental Laboratory in accordance with the Programmatic SNF EIS Record of Decision.

2.4.6 ALTERNATIVES NOT ANALYZED IN DETAIL

DOE considered dry storing aluminum-based SNF (with no treatment or packaging) as a possible alternative for evaluation in this EIS. The first step for dry storing aluminum-based SNF would be accomplished by constructing a dry transfer facility. Fuel would be removed from wet storage in transfer casks, transported to the dry transfer facility, and removed from the transfer cask. Then the fuel would be placed in dry storage without any characterization, repackaging, or treatment that would be done under the New Packaging Technology alternative or New Processing Technology alternative. DOE decided not to evaluate this alternative because it would not meet the purpose and need for agency action (i.e., it would not prepare SNF for placement in a geologic repository). In order to prepare fuel for disposition, DOE would still have to implement the New Packaging Technology, New Processing Technology, or Conventional Processing alternatives, and dry storage is already analyzed as a component of these alternatives as applicable.

DOE considered a variation to the Chemical Processing Technology option where the dissolved Experimental Breeder Reactor-II fuel would be transferred to the high-level waste tanks at the SRS for subsequent vitrification in the Defense Waste Processing Facility. DOE evaluated this action under the *Interim Management of Nuclear Materials Final Environmental Impact Statement* (DOE 1995c) for material that is very similar to the Experimental Breeder Reactor-II fuel (i.e., Mark-31 targets and Taiwan Research Reactor SNF). In that EIS, DOE concluded that the process of transferring more than trace quantities of fissile material to the high-level waste tanks with subsequent vitrification was techni-

cally very complex and that it would take at least 6 years to develop the process. DOE noted that the Department would have to develop a process that would render fissile materials incapable of producing a nuclear criticality, regardless of the location or amount accumulated in various equipment or tanks. DOE postulated that this could be accomplished by the addition of a chemical or other material to serve as a nuclear "poison," which would minimize the potential for a criticality. However, the nuclear poison would have to be designed to accompany the fissile material throughout the process or different poisons would have to be used at different process steps (evaporation, concentration, precipitation, and ultimately vitrification). For these reasons, DOE does not consider this technology/fuel option reasonable for analysis in this EIS. Instead, DOE has analyzed the Dissolve and Vitrify option in the EIS, which would accomplish the same purpose as transferring the dissolved Experimental Breeder Reactor-II fuels to the high-level waste tanks for vitrification in the Defense Waste Processing Facility.

2.5 Comparison of Environmental Impacts Among Alternatives

Chapter 4 presents the predicted operational impacts, potential accident impacts, and construction impacts for each technology option and alternative. This organization enables the evaluation of recurring impacts (i.e., impacts from normal operations) independent of the infrequent impacts of accidents and the one-time impacts of construction.

As discussed in Section 1.3, DOE believes the amount of foreign research reactor SNF to be received in the U.S. could decrease from about 18 metric tons heavy metal (MTHM) to about 14 MTHM (or less). Therefore, the actual amount of aluminum-based material could be less than the 48 MTHM evaluated in this EIS. The only effect would be a small reduction of environmental impacts described in this EIS. DOE does not believe a reduction of this magnitude would materially affect the impacts associated

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with normal operations involving Material Test Reactor-like fuels (Fuel Group B) and the reduction would occur across all alternatives. However, where it is applicable, DOE has included information in the impact tables for normal operations that provide an example of how the reduced Fuel Group B impact data could be calculated.

The potential reduction in foreign research reactor SNF receipts would have no effect on the accident impact data that are presented in the EIS because none of the postulated accidents could affect all the fuel at once. Processing related accidents would affect only the "batch" of fuel that was involved in the process operation and accidents that could affect stored fuel, such as an earthquake, would be unlikely to involve all the fuel in the storage facility.

Impacts from normal operations under all of the alternatives would have little if any effect on ecological resources, water resources, or cultural resources. The impacts from incident-free onsite transportation of SNF would be minimal under all alternatives.

Processing the Mark-18 targets (about 1 kilogram of heavy metal) was previously analyzed in the *Final Environmental Impact Statement on Interim Management of Nuclear Materials* and, therefore, was not analyzed in this EIS. The impacts of processing this small amount of material are minor and would not significantly affect the impacts analyzed for the Maximum Impact Alternative in this EIS. For example, total radiological dose from the Preferred Alternative to the maximally exposed individual for the entire period of analysis would be 0.67 millirem. Processing the Mark-18 targets would result in a dose of 0.0035 millirem.

Table 2-10 lists impacts for the five selected alternatives. The EIS identifies the following operational impacts with the potential to discriminate among the alternatives:

- *Worker and public health impacts* – Estimated impacts are reported as latent cancer

fatalities for the involved worker population, noninvolved worker, the maximally exposed member of the public, and offsite population. These impacts are summed over the period of analysis based on annual emissions and radiation doses.

Involved worker doses assume that no worker would receive more than the SRS administrative annual limit of 700 millirem. Based on this, the estimated latent cancer fatalities for the involved worker population for the entire period of analysis would range from 0.28 for the Minimum Impact Alternative to 0.84 for the Maximum Impact Alternative.

The values in Table 2-10 for health effects to the noninvolved worker, maximally exposed individual, and the offsite population for the No-Action Alternative represent current reactor-area emissions (including two SNF wet basins) for the entire period of analysis. The values for the other alternatives would be incremental above these baseline values. Summing these baseline and incremental values would be conservative, however, because there would not be two SNF wet basins operating over the entire 38-year period of analysis.

The noninvolved worker highest estimated probability of a latent cancer fatality over the entire period of analysis would range from 2.0×10^{-9} for the Minimum Impact Alternative to 6.3×10^{-7} for the Maximum Impact Alternative.

The estimated latent cancer fatality probability to the maximally exposed individual over the entire period of analysis would range from 3.0×10^{-10} (Minimum Impact Alternative) to 3.4×10^{-7} (Maximum Impact Alternative). The estimated latent cancer fatalities in the offsite population affected by SRS over the entire period of analysis would be much less than 1 for any alternative. These estimated offsite latent cancer

Table 2-10. Impact summary by alternative.

	Parameter	No Action Alternative (baseline)	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative
Health Effects for the Entire Period of Analysis (1998-2035)						
TC	Latent cancer fatality probability for the noninvolved worker	$1.7 \times 10^{-6(a)}$	2.0×10^{-9}	9.6×10^{-9}	6.1×10^{-7}	6.3×10^{-7}
	Latent cancer fatality probability for the maximally exposed member of the public	$3.1 \times 10^{-7(a)}$	3.0×10^{-10}	3.6×10^{-9}	9.5×10^{-8}	3.4×10^{-7}
	Latent cancer fatalities for the worker population	0.30	0.28	0.34	0.33	0.84
	Latent cancer fatalities for the general public	$1.1 \times 10^{-2(a)}$	1.1×10^{-5}	3.8×10^{-5}	3.4×10^{-3}	4.4×10^{-3}
Waste Generation Required for the Entire Period of Analysis (1998-2035)						
TC	Liquid (cubic meters)	2,300	660	1,200	1,050	10,500
	High-level waste generated (equivalent DWPF ^b canisters)	38	11	20	17	160
	Transuranic waste generated (cubic meters)	0	15	360	563	3,700
	Hazardous and mixed low-level waste generated (cubic meters)	76	25	46	103	267
	Low-level waste generated (cubic meters)	57,000	20,000	31,000	35,260	140,000
Utilities and Energy Required for the Entire Period of Analysis (1998-2035)						
	Water consumption (millions of liters)	1,100	660	1,400	1,186	8,000
	Electricity consumption (megawatt-hours)	46,000	27,000	81,000	116,000	600,000
	Steam consumption (millions of kilograms)	340	190	520	650	3,600
	Diesel fuel consumption (thousands of liters)	230	180	2,300	2,760	22,000
	Road-ready Repository canisters (1998-2035)	0	~1,400	~1,300	~400	0 ^c

a. Reflects current reactor-area emissions (including two SNF wet basins) for the entire period of analysis.

b. DWPF = Defense Waste Processing Facility.

c. The technology used in the Maximum Impact Alternative (i.e., Conventional Processing) would produce only high-level waste.

Table 2-11. Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each fuel group and technology (percent of regulatory standard).

Fuel group	Technology						
	1. Prepare for Direct Co-Disposal	2. Repackage and Prepare to Ship ^a	3. Melt and Di- lute	4. Mechanical Dilution	5. Vitrification Technologies	6. Electro- metallurgical Treatment	7. Conventional Processing
A. Uranium and Thorium Metal Fuels	0.02 (ozone [as VOC])	NA	0.03 (ozone [as VOC])	No	1.1 (nitrogen ox- ides)	0.03 (ozone [as VOC])	1.1 (nitrogen ox- ides)
B. Materials Test Reactor-Like Fuels	0.03 (ozone [as VOC])	NA	0.05 (ozone [as VOC])	0.03 (ozone [as VOC])	1.7 (nitrogen ox- ides)	0.05 (ozone [as VOC])	1.7 (nitrogen ox- ides)
C. HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging	0.01 (ozone [as VOC])	NA	0.02 (ozone [as VOC])	0.01 (ozone [as VOC])	0.55 (nitrogen ox- ides)	0.02 (ozone [as VOC])	0.55 (nitrogen ox- ides)
D. Loose Uranium Oxide in Cans	NA	NA	<0.004 (ozone [as VOC])	NA	0.06 (nitrogen ox- ides)	<0.002 (ozone [as VOC])	0.06 (nitrogen ox- ides)
E. Higher Actinide Targets	NA	<0.004 (ozone [as VOC])	NA	NA	NA	NA	NA
F. Non-Aluminum-Clad Fuels	NA	NA	NA	NA	NA	NA	NA

NA = Technology is not applicable to this fuel type.
VOC = volatile organic compound.

Table 2-12. Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each alternative (percent of regulatory standard).

No Action Alternative	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative
0.03 (nitrogen oxides)	0.07 (ozone [as VOC])	1.2 (nitrogen oxides)	1.1 (nitrogen oxides)	3.6 (nitrogen oxides)

VOC = volatile organic compound.

fatalities would range from 1.1×10^{-5} to 4.4×10^{-3} .

- *Nonradiological Air Quality* – Table 2-11 presents the estimated maximum incremental concentrations of the nonradiological air pollutants that would contribute the most to the deterioration of air quality at the SRS boundary. Concentrations are presented for each technology fuel group concentration. The incremental concentrations would not affect human health. Table 2-12 presents the estimated maximum incremental concentration of the nonradiological air pollutant that would contribute the most to the deterioration of air quality at the SRS boundary for each alternative. As noted from Table 2-12, the concentration of the nonradiological constituent contributing the highest fraction of the offsite air quality standard would range from 0.03 percent of the standard for the No-Action Alternative to 3.6 percent of the standard for the Maximum Impact Alternative. Under all alternatives, nonradiological air concentrations of the SRS boundary would be well below applicable standards.
- *Waste generation* – Wastes volumes were estimated over the period of analysis. The Maximum Impact Alternative would generate the greatest volume of high-level waste, while the Minimum Impact Alternative would generate the least volume of high-level waste. For wastes generated under all alternatives, DOE would use the surplus capacity in existing SRS waste management facilities to treat, store, dispose, or recycle the waste in accordance with applicable regulations.

- *Utilities and energy consumption* – The quantities of water, electricity, steam, and diesel fuel that would be required over the entire period of analysis were estimated.

The Maximum Impact Alternative would require the most water, electricity, steam, and diesel fuel, while the Minimum Impact Alternative would require the least. For all alternatives, water and steam would be obtained from existing onsite sources and electricity and diesel fuel would be purchased from commercial sources. These commodities are readily available and the amounts required would not have an appreciable impact on available supplies or capacities.

Accidents – DOE evaluated the impacts of potential facility accidents related to each of the alternatives. For each potential accident, the impacts were evaluated as radiation dose to the noninvolved worker, radiation dose to the offsite maximally exposed individual, collective radiation dose to the offsite population, and latent cancer fatalities to the offsite population. Table 2-13 presents the results of this analysis. Table 2-13 also indicates the estimated frequency of occurrence for each accident.

The highest consequence accident postulated under the continued wet storage, direct co-disposal, and repackaging and prepare to ship technologies is a seismic/high wind-induced criticality, which is estimated to

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Table 2-13. Estimated maximum consequence accident for each technology.

Option	Accident Frequency	Consequences			
		Noninvolved Worker (rem)	MEI (rem)	Offsite Population (person-rem)	Latent Cancer Fatalities
Continued Wet Storage (No Action) ^a					
RBOF (high wind-induced criticality)	Once in 26,000 years	13	0.22	12,000	6.2
L-Reactor basin (basin-water draindown)	Once in 500 years	0.014	0.016	(b)	(b)
Direct Co-Disposal					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Repackage and Prepare to Ship					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Conventional Processing					
Processing phase in F/H Canyons (coil and tube failure)	Once in 14,000 years	13	1.3	78,000	39
Melt and Dilute					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Melt and dilute phase (earthquake induced spill with loss of ventilation)	Once in 200,000 years	30	0.5	21,000	10
Mechanical Dilution					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Mechanical dilution phase (criticality with loss of ventilation)	Once in 33,000 years	0.71	0.074	3,000	1.5
Vitrification Technologies					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Vitrification phase (earthquake-induced release with loss of ventilation)	Once in 200,000 years	0.10	0.0017	71	0.035
Electrometallurgical Treatment					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Electrometallurgical phase (metal melter earthquake induced spill with loss of ventilation)	Once in 200,000 years	30	0.5	21,000	10

MEI = Maximally Exposed Individual.

RBOF = Receiving Basin for Offsite Fuels.

a. All alternatives would use RBOF and the L-Reactor Disassembly Basin; therefore, accidents in these facilities are possible for each technology.

b. Not available.

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result in 6.2 latent cancer fatalities in the off-site population. The highest consequence accident under conventional processing technology is a coil and tube failure with an estimated offsite population impact of 39 latent cancer fatalities. The frequencies of these accidents are once in 2,000 to once in 26,000 years.

For the other new SNF technologies evaluated, the maximum consequence accident (earthquake induced spill with loss of ventilation) is associated with the melt and dilute process. This accident is estimated to occur once in 200,000 years and to result in 10 latent cancer fatalities in the offsite population.

Construction activities could affect four parameters: surface-water quality, air quality, ecological resources, and socioeconomics. However, because current SRS construction workers would build the facilities in an existing industrialized area of the Site, DOE expects little impact from construction activities.

2.6 Other Decisionmaking Factors

2.6.1 TECHNOLOGY AVAILABILITY AND TECHNICAL FEASIBILITY

The New Packaging and New Processing Technology Alternatives would rely on technologies that have not been applied to the management of aluminum-based SNF for ultimate disposition. Therefore, DOE conducted a feasibility study of the non-processing technologies and documented the study in a report prepared by a Research Reactor Task Team in its Office of Spent Fuel Management (DOE 1996b).

The Research Reactor Task Team examined a wide range of technical issues involved in achieving safe and cost-effective disposal of aluminum-based SNF under DOE jurisdiction. The Team identified and evaluated issues on technical grounds to arrive at a recommended course of action that could lead to the implementation of a non-processing SNF management technology by 2000. The team considered three specific areas

of investigation to be key: (1) repository and waste form considerations; (2) SNF receipt, handling, and storage provisions; and (3) treatment technologies (the same technologies this EIS considers). The team assigned the highest confidence of success and greatest technical suitability to technologies that would have relatively simple approaches (i.e., Direct Disposal, Direct Co-Disposal, Melt and Dilute, and Press and Dilute). The Conventional Processing option would have the least technical uncertainty because it would rely largely on a technology that is proven for aluminum-based SNF. The No-Action Alternative would involve the greatest technical uncertainty in the area of potential fuel degradation, as a result of continued long-term wet storage in SRS basins. The non-processing technologies with the greatest technical uncertainties would be the more complicated technologies such as vitrification.

In response to a DOE request, the National Academy of Sciences evaluated and provided recommendations for DOE's aluminum-based SNF disposition technical program (NAS 1998). The NAS report was prepared by a Principal Investigator assisted by a panel of expert consultants in fields of nuclear criticality control, proliferation policy, costs and schedules, corrosion and metallurgy, processing and remote handling, and regulatory waste acceptance.

The panel reviewed the DOE program for developing a strategy for treatment of aluminum-based SNF in preparation for interim storage and final disposal, with emphasis on the following objectives:

- Evaluation of the set of technologies proposed by DOE for aluminum-based SNF treatment, with suggestions of other applicable technologies
- Examination of waste package performance criteria developed by DOE to meet the anticipated waste acceptance criteria for storage, transportation, and repository disposal

L3-3

- Assessment of projected costs and schedule for implementation of the aluminum-based SNF technologies

The NAS report generally endorsed the projected DOE spent fuel disposition scenarios under development. The NAS recommendations for systems approach and phased strategy were incorporated by DOE into the EIS as follows:

Two systems analyses were completed for the primary new technologies being considered by DOE (Melt and Dilute and Direct Disposal/Direct Co-Disposal). A variety of attributes were evaluated, including cost, criticality concerns, public safety, worker safety, environmental concerns, nonproliferation, versatility, maintainability, and repository volume. One analysis was performed by Westinghouse Savannah River Company (WSRC 1998b), and a second independent multi-attribute decision analysis was completed by Sandia National Laboratory (SNL 1998). In both studies, Melt and Dilute had the least uncertainty.

DOE has recognized the advantages of applying a phased strategy for implementation of the melt and dilute process and continues to integrate its development and installation with other site program priorities and schedules in mind. The NAS concern regarding technology selection being driven by post-2015 SNF receipts is mitigated by the plan to design a facility with minimal-sized processing capabilities, which will be able to treat the current inventory of spent nuclear fuels within a reasonable timeframe, yet not be operationally burdensome when fuel receipts are reduced to minimal amounts.

The phased strategy was accommodated by provisions of backup treatments for appropriate fuel types should the projected preferred treatments not be successfully implemented within required time constraints. For example, the Direct Disposal/Direct Co-disposal technology is included as a backup technology for Melt and Dilute technology.

In summary conclusions, the NAS noted the complexity of the aluminum-based SNF disposal program including factors such as: the timely provision of initial storage capacity for the fuel at SRS; the selection, development, and implementation of one or more treatment options to qualify the fuel for possible repository disposal; and the interim storage required until the repository, yet-to-be designed, licensed, or constructed, can accept it. The Academy noted that an SNF disposition program requires a systems approach for optimization of the many interacting factors required for successful implementation. The NAS recommended that aluminum-based SNF treatment decisions be made using a phased strategy in which critical decisions are made as the information needed for sound choices becomes available, recognizing the trade-offs between information acquisition and costs of delayed decisions.

The NAS panel identified a number of specific findings with recommendations as described in their report (NAS 1998).

Specific observations of the panel included the following:

- DOE has identified a reasonably complete set of aluminum-based SNF treatment options, resulting in selection of the Direct Co-Disposal and Melt and Dilute technologies for further development.
- The selection of a preferred treatment alternative must take into account uncertainties in repository Waste Acceptance Criteria that could, for example, disqualify highly enriched uranium waste forms such as produced by the Direct Co-Disposal technology.
- Both the Direct Disposal/Direct Co-Disposal and Melt and Dilute technologies apparently can be implemented to produce acceptable waste forms. The high-temperature Melt and Dilute treatment is technically more demanding than the relatively straight-forward Direct Disposal/ Direct Co-Disposal treatment and presents potential problems in ra-

EC dioactive off-gas control, but the basic operations have been demonstrated in other programs. Suitability of other technology options, such as the Electrometallurgical Treatment, is less assured because of the additional development work needed.

- More careful consideration of the conventional processing option is needed, because it is a well-demonstrated technology, its costs and risks are known, the necessary facilities are in current operations, and the high-level waste form is likely acceptable in the repository.
- DOE has established a working relationship with DOE-Yucca Mountain and plans to continue this relationship to ensure timely identification of repository waste form criteria and waste characterization requirements.
- Other waste form criteria, including interim-storage criteria, appear reasonable and complete, except for transportation requirements. The panel recommended DOE review shipping requirements before finalization of canister/shipping cask design for the waste forms.
- Work under way by DOE-SR appears properly focused and appropriate to the above requirements. However, a single treatment option may not be suitable for all types of aluminum-clad SNF and the program should maintain flexibility in technology selection to accommodate this variability.
- Major cost factors are accounted for in the cost projections, but schedule projections appear ambitious, and schedule delays could affect the cost projections. Projected costs are, however, not a major discriminator of the various treatments and treatment selection can proceed based on current projections.

The DOE-SR and the Nuclear Regulatory Commission (NRC) have established an agreement for the NRC to provide technical assistance in connection with the identification of potential issues

relating to the placement of aluminum-based foreign and domestic research reactor spent nuclear fuel in a geologic repository. In a recent review of DOE's research and development work, the NRC staff indicated that both the Melt and Dilute and Direct Co-Disposal technologies would be acceptable concepts for the disposal of aluminum-based research reactor SNF in a repository (Knapp 1998).

2.6.2 NONPROLIFERATION, SAFEGUARDS AND SECURITY

On May 13, 1996, the United States established a new 10-year policy to accept and manage foreign research reactor spent nuclear fuel containing uranium enriched in the United States (61 FR 25091). The goal of this policy is to reduce civilian commerce in weapons-usable highly enriched uranium, thereby reducing the risk of nuclear weapons proliferation, as called for in President William Clinton's September 27, 1993, Nonproliferation and Export Control Policy.

Two key disposition options under consideration for managing SNF in this EIS include conventional processing and new treatment and packaging technologies. The Record of Decision for managing foreign research reactor SNF specified that, while evaluating the processing option, "DOE will commission or conduct an independent study of the nonproliferation and other (e.g., cost and timing) implications of chemical separation of spent nuclear fuel from foreign research reactors." DOE's Office of Arms Control and Nonproliferation conducted the study. To receive a copy, contact DOE at 1-800-881-7292.

The study addresses the nonproliferation implications the Department considered in determining how to manage aluminum-based SNF at the Savannah River Site, including how to place these materials in forms suitable for ultimate disposition (DOE 1998a). Because the same technology options are being considered for the foreign research reactor and the other aluminum-based spent nuclear fuels, the report addresses the nonproliferation implications of managing all the Savannah River Site aluminum-based SNF.

The nonproliferation assessment evaluates the extent to which each technology option supports the United States nonproliferation goals, which are summarized below.

- To reduce the risk of nuclear proliferation and for other considerations, the United States neither encourages the civil use of plutonium nor engages in plutonium processing for either nuclear power or nuclear explosive purposes. In addition, the United States works actively with other nations to reduce global stocks of excess weapons-usable material; separated plutonium and highly enriched uranium. Under this policy, the United States honors its commitments to cooperate with civilian nuclear programs that involve the processing and recycling of plutonium in Western Europe and Japan. In all such cases, however, the United States seeks to ensure that the International Atomic Energy Agency (IAEA) has the resources needed to implement its vital safeguards responsibilities, and works to strengthen the IAEA's ability to detect clandestine nuclear activities. The United States seeks to eliminate where possible the accumulation of stockpiles of highly enriched uranium or plutonium, and to ensure that where these materials already exist they are subject to the highest standards of safety, security, and international accountability. The United States also actively opposes, as do other supplier nations, the introduction of processing and plutonium recycling activities in regions of proliferation concern.
- The United States also seeks to minimize the adverse environmental, safety, and health impacts of its management of nuclear materials and activities. This goal includes minimizing the generation of radioactive wastes and ensuring that waste materials are put into forms that can be disposed of safely.

To evaluate the extent to which the technology options support the United States' nonproliferation policy goals, the nonproliferation study

evaluated the technology options using technical and policy factors, as explained below.

Technical factors include the degree to which a particular technology would:

- Help ensure that the weapons-usable nuclear material in the spent nuclear fuel could not be stolen or diverted during the process. This includes an assessment of the attractiveness to diversion of materials in process and the ease of providing institutional and inherent security features.
- Facilitate cost-effective international verification and transparency.
- Result in converting the spent nuclear fuel into a form from which retrieval of the material for weapons use would be difficult and unlikely, thus modestly reducing the total stockpile of material readily usable in nuclear weapons.

Policy factors include the degree to which a particular technology would:

- Be consistent with United States policy related to processing and nonproliferation.
- Avoid encouraging other countries to engage in the processing of spent nuclear fuel, or undermining United States efforts to limit the spread of processing technology and activities, particularly to regions of proliferation concern.
- Support United States efforts to convert United States and foreign research reactors to low enriched fuels, and avoid creating technical, economic, or political obstacles to implementing the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program.
- Help demonstrate that any treatment of these spent nuclear fuels will definitely not represent the production by the United States of additional materials for use in nuclear weapons.

- Support negotiation of a nondiscriminatory global fissile material cutoff treaty.

There are several options for the effective management of the aluminum-based SNF at SRS.

With respect to nonproliferation, the report concluded the following:

- All of the options could reliably discourage any theft or diversion of the material, but some are superior to others.
- All of the options could provide for some form of international safeguarding by the International Atomic Energy Agency (IAEA). The options vary in terms of cost and ease of application.
- All of the options would result in forms from which recovery of the material for use in weapons would be highly unlikely, although the Direct Disposal/Direct Co-Disposal Option would not blend down the residual highly enriched uranium and low enriched uranium, and the conventional processing option would recover plutonium metal that would be managed as surplus.
- All of the options would be consistent with United States nonproliferation policy, and would allow for verification approaches that would be acceptable to the United States if implemented in other countries.
- The electrometallurgical treatment and the conventional processing, by appearing to endorse these technologies, could conceivably encourage processing in other countries.
- All of the options have the potential to support fully United States efforts to reduce the civil use of highly enriched uranium, including the Foreign Research Reactor Spent Nuclear Fuel Acceptance Program.
- None of these options would appear to be prejudicial to the ability of the United States to submit to international safeguards or

monitoring under a nondiscriminatory fissile material cutoff treaty. However, the processing option involves the use of old facilities at the Savannah River Site not specifically designed to facilitate the application of international safeguards. An effective safeguarding regime would likely be difficult due to cost and safety retrofitting concerns (DOE 1998a).

- The Office of Arms Control and Nonproliferation fully supports the active pursuit of a new treatment technology for the aluminum-based spent nuclear fuel, and views the melt and dilute recommendation as a favorable technology in light of nonproliferation concerns.

2.6.3 LABOR AVAILABILITY AND CORE COMPETENCY

Each alternative and associated technologies would require different levels of personnel knowledge and training. In addition, providing the needed level of training would result in impacts, primarily in the area of personnel resources. In general, the New Packaging options probably would be the least labor-intensive. The Conventional Processing option or a combination of options that included conventional processing would be the most labor-intensive to implement on an annual basis.

Operations required for the Conventional Processing technology would occur in parallel with other canyon nuclear stabilization programs. As a result, no excess personnel would be available in the event the vulnerable SNF was not processed. Because the canyons already would be operating to process materials not considered in this EIS, there also would be no actual cost savings that could be transferred to another activity.

The Conventional Processing technology option and No-Action Alternative would require the least amount of training because the SRS workforce has a great deal of experience in these technologies and there are existing training and qualification programs to maintain core compe-

L2-12

tency. The New Processing Technology options such as Vitrification Technologies or Electrometallurgical Treatment probably would require the greatest training effort because they would involve new and complex operations.

2.6.4 MINIMUM CUSTODIAL CARE

The New Packaging Technology and New Processing Technology options would create a form of material that required the least amount of custodial care before shipment off the Site. However, safeguards and security requirements would still be maintained. Conventional processing would require care of the vitrified waste similar in level-of-effort to the custodial care of the New Packaging and New Processing Technology option. In addition, it also would require care of the high-level waste until it was vitrified and any blended-down fissile material until they were delivered for disposition.

2.6.5 COST

To determine the potential cost of integrating various combinations of alternatives, DOE has estimated life-cycle costs for the alternatives and for the new technology options described in this EIS and for conventional processing. The cost report was prepared, in part, to satisfy the Department's commitment to study the implications of chemically separating SNF (see Section 2.6.2). The planning level costs have an uncertainty of +50 percent to -30 percent. These estimates, which are listed in Table 2-14, include both op-

erating and capital (i.e., construction) costs (DOE 1998b).

DOE estimated the costs for the alternatives discussed in this EIS using the technology option cost information from the cost study. The cost estimates for the alternatives are presented in Table 2-15.

Comparison of the projected life cycle costs for the alternatives indicate the following:

- The life-cycle costs range from a low of \$1.7 billion for No Action to a high of \$2.0 billion for the Maximum Impact Alternative. However, the continued wet storage cost does not include actions necessary to prepare SNF for ultimate disposition.
- The Direct Disposal Alternative (\$1.9 billion) and the Preferred Alternative (\$2.0 billion) (both using a renovated reactor building) have approximately the same life-cycle cost, with installation in a renovated reactor facility presenting cost advantages of about \$200 million compared to a new treatment facility.
- The cost of processing the SNF proposed in the Preferred Alternative would be incremental to the cost of operating the canyons for other reasons and very small when compared to the canyon overall operating cost.

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Table 2-14. Life-cycle costs for aluminum-clad fuel technologies (1998 millions of dollars)^a.

Table 2-15. Life-cycle costs (1998 billions of dollars) for each alternative.^a

Minimum Impact	Direct Disposal	Preferred Alternative	Maximum Impact	No Action
1.9 ^b	1.9	2.0 ^c	2.0	1.7

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- a. Source: DOE (1998b).
b. Includes less than \$30 million to install Melt and Dilute capability for Fuel Group D.
c. Includes about \$6 million as direct and indirect cost of operating canyons for SNF processing during 1999-2001 while the material stabilization program is underway in response to Defense Nuclear Facility Safety Board Recommendation 94-1.

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CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES	1
2.1 Proposed Action	1
2.2 Spent Nuclear Fuel Management Technology Options	2
2.2.1 Repository Considerations	4
2.2.2 Facilities.....	7
2.2.3 New Packaging Technology OptionS.....	8
2.2.3.1 Prepare for Direct Disposal/Direct Co-Disposal	8
2.2.3.2 Repackage and Prepare to Ship to Other DOE Sites	9
2.2.4 New Processing Technology options.....	9
2.2.4.1 Melt and Dilute.....	12
2.2.4.2 Mechanical Dilution.....	13
2.2.4.3 Vitrification Technologies	17
2.2.4.4 Electrometallurgical Treatment	18
2.2.5 Conventional Processing Technology.....	19
2.3 Spent Nuclear Fuel Management Facilities	20
2.3.1 Existing Facilities	20
2.3.1.1 L-Reactor Facility.....	20
2.3.1.2 Receiving Basin for Offsite Fuel	20
2.3.1.3 F and H Canyons.....	26
2.3.2 Proposed Facilities.....	27
2.3.2.1 Transfer and Storage Facility	27
2.3.2.2 Transfer, Storage, and Treatment Facility	33
2.4 Alternatives Evaluated	38
2.4.1 Minimum Impact Alternative	38
2.4.2 Maximum Impact Alternative.....	40
2.4.3 Preferred Alternative.....	41
2.4.3.1 Melt And Dilute.....	41
2.4.3.2 Conventional Processing	44
2.4.3.3 Repackaging.....	44
2.4.3.4 Continued Wet Storage.....	46
2.4.4 Direct Disposal Alternative	46
2.4.5 No-Action Alternative: Continued Wet Storage	47
2.4.6 Alternatives Not Analyzed in Detail	48
2.5 Comparison of Environmental Impacts Among Alternatives.....	48
2.6 Other Decisionmaking Factors	54
2.6.1 Technology Availability and Technical Feasibility	54
2.6.2 Nonproliferation, Safeguards and Security	56
2.6.3 Labor Availability and Core Competency	58
2.6.4 Minimum Custodial Care.....	59
2.6.5 Cost	59
References.....	62

List of Tables

Table 2-1. Applicability commentary of the New Packaging Technology options.

11

Table 2-2. Applicability of New Processing Technology options.	16
Table 2-3. Comparison of preferred and backup technologies for aluminum-SNF disposal.	17
Table 2-4. Facilities needed for SNF technologies.	22
Table 2-5. Transfer and Storage Facility functions.	29
Table 2-6. Road-ready storage capacities.	31
Table 2-7. Fuel groups and technology options that could be applied to meet the purpose and need. For each fuel group, the technologies that would produce the lowest and highest impacts have been identified.	37
Table 2-8. Alternatives analyzed in this EIS.	39
Table 2-9. The fuel group technology configurations that compose the preferred alternative.	42
Table 2-10. Impact summary by alternative.	50
Table 2-11. Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each fuel group and technology (percent of regulatory standard).	51
Table 2-12. Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each alternative (percent of regulatory standard).	52
Table 2-13. Estimated maximum consequence accident for each technology.	53
Table 2-14. . Life-cycle costs for aluminum-clad fuel technologies (1998 millions of dollars).	60
Table 2-15. Life-cycle costs (1998 billions of dollars) for each alternative. ^a	61

List of Figures

Figure 2-1. New Packaging Technology – Direct Disposal/Direct Co-Disposal.....	12
Figure 2-2. New Packaging Technology – Repackage and Prepare to Ship to Another DOE site.	12
Figure 2-3. New Processing Technology - Melt and Dilute, Mechanical Dilution, Vitrification Technologies.	15
Figure 2-4. New Processing Technology – Electrometallurgical Treatment.	15
Figure 2-5. Conventional Processing.....	22
Figure 2-6. SRS map indicating locations of facilities needed for Proposed Action.....	24
Figure 2-7. Plan view of the L-Reactor facility.....	25
Figure 2-8. Canyon building sections.	27
Figure 2-9. H Canyon and surrounding area (view toward northeast).....	28
Figure 2-10. Schematic cut-away of the transfer storage and treatment facility.	30
Figure 2-11. Typical spent nuclear fuel dry storage facilities.	32
Figure 2-12. Plan view of C-Reactor facility.	34
Figure 2-13. Potential Transfer, Storage, and Treatment Facility location in F Area.....	35
Figure 2-14. Potential Transfer, Storage, and Treatment Facility location in H Area.	36
Figure 2-15. Preferred Alternative Management Flow-Path.	43
Figure 2-16. No Action Alternative-Continued Wet Storage.....	44

accident, 8, 45, 49, 50
Accident, 50
accidents, 45, 49, 50
Accidents, 49
aluminum-based SNF, 1, 2, 4, 7, 8, 9, 12, 15, 18, 37, 40, 41, 42, 44, 49, 51, 52, 53, 54
aluminum-based spent nuclear fuel, 44, 53, 55
canyon, 1, 2, 24, 42, 55, 57
canyons, 1, 16, 24, 26, 37, 41, 42, 55, 57
Chop and Dilute, 2, 15, 16
construction impacts, 45
conventional processing, 2, 3, 20, 37, 41, 42, 49, 52, 55
core filter block, 41, 42
criticality, 1, 3, 6, 8, 11, 12, 15, 16, 17, 23, 30, 40, 45, 49, 50, 51
Defense Nuclear Facilities Safety Board, 20, 23, 26, 58
Defense Waste Processing Facility, 2, 28, 45
Direct Co-disposal, 51
Direct Disposal, 2, 4, 6, 8, 9, 11, 20, 28, 35, 40, 43, 49, 51, 52, 54, 57
Dissolve and Vitrify, 2, 16, 28, 45
DOE, 1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 15, 16, 17, 18, 19, 20, 23, 24, 26, 28, 30, 35, 37, 40, 41, 42, 43, 44, 45, 47, 49, 51, 52, 53, 55, 57, 58, 59
domestic research reactor fuel, 19
DWPF, 2, 9, 16, 18, 28
ecological resources, 49
Electrometallurgical Treatment, 2, 3, 6, 12, 13, 17, 20, 28, 30, 50, 52, 55
energy consumption, 47
Environmental Protection Agency, 6, 59
EPA, 6
Experimental Breeder Reactor-II fuel, 18, 41, 42, 45
F Canyon, 1, 17, 18, 24, 26, 37, 41, 42, 50
FB-Line, 18, 42
foreign research reactor fuel, 1
fuel corrosion, 41
geologic repository, 1, 2, 4, 6, 8, 11, 12, 15, 16, 17, 18, 26, 37, 40, 41, 43, 44, 52
Glass Material Oxidation Dissolution System, 16
Group B, 45
Group D, 57
Group E, 4, 9
Group F, 9
H Canyon, 1, 17, 18, 19, 20, 24, 25, 26, 37, 41, 42, 44, 50
heavy metal, 42, 45
HEU, 35, 37, 41, 42, 43
high-level waste, 3, 5, 6, 9, 16, 18, 28, 35, 45, 47, 52, 55
highly-enriched uranium, 6, 8, 17
Idaho National Engineering and Environmental Laboratory, 9, 18, 43, 44
impacts, 9, 15, 16, 28, 30, 35, 37, 40, 44, 45, 49, 53, 55
latent cancer fatalities, 45, 47, 49
LEU, 35, 37, 41, 42, 43
low-level waste, 17, 19
L-Reactor Disassembly Basin, 8, 11, 12, 18, 20, 23, 26, 30, 43, 50
Mark-18 targets, 9, 37, 42
Mark-42 targets, 18, 37, 41, 42, 43
maximally exposed individual, 47, 49
maximum impact alternative, 37
melt and dilute, 7, 12, 40, 41, 42, 43, 51, 55
Melt and Dilute, 2, 4, 6, 12, 13, 15, 16, 20, 28, 30, 37, 40, 42, 43, 49, 50, 51, 52, 57
minimum impact alternative, 35
National Academy of Sciences, 7, 12, 51, 59
non-aluminum-based SNF, 17
nonproliferation, 1, 6, 16, 40, 51, 53, 54, 55
NRC, 4, 5, 6, 7, 15, 52
Nuclear Regulatory Commission, 4, 15, 52, 59
offgas, 15
off-gas, 40, 52
off-gas system, 40
Office of Arms Control and Nonproliferation, 53, 55, 58
Office of Civilian Radioactive Waste Management, 58
Plasma Arc Treatment, 2, 16, 17, 28
plutonium, 3, 7, 18, 24, 42, 53, 54
Plutonium, 18, 42
preferred alternative, 37, 38, 40, 61
Preferred Alternative, 35, 37, 39, 43, 49, 57,
Press and Dilute, 2, 4, 15, 16, 49
process, 1, 2, 12, 15, 16, 17, 20, 24, 30, 40, 42, 45, 51, 54, 55
radiation dose, 45, 49
Receiving Basin for Offsite Fuel, 8, 11, 12, 18, 19, 20, 23, 24, 26, 41, 42, 43, 49, 50
Recommendation 94-1, 57, 58

Repackaging, 8, 9, 43
repository, 1, 4, 5, 7, 8, 9, 15, 18, 26, 35, 40, 43,
49, 51, 52
processing, 1, 16, 26, 42, 53, 54
Savannah River Site, 1, 44, 53, 55, 58, 59
separations, 2, 24, 42, 43
shipping container, 7, 26
shipping containers, 7, 26
Sodium Reactor Experiment fuel, 41, 42
Sterling Forest Oxide fuel, 42, 43
Transfer and Storage Facility, 7, 8, 9, 19, 20, 26,
28, 30, 35, 43, 59

Transfer, Storage, and Treatment Facility, 7, 8,
9, 11, 12, 15, 16, 17, 18, 19, 20, 30, 32, 33,
37
transportation, 8, 26, 44, 51, 52
U.S. Department of Energy, 1, 58, 59
uranium, 1, 3, 4, 6, 7, 8, 12, 15, 16, 17, 18, 24,
26, 35, 37, 40, 41, 42, 43, 52, 53, 54
vitrification, 16, 42, 45, 51
waste acceptance criteria, 15, 26, 51
waste generation, 35, 40
worker health, 7, 35